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FISHERIES BULLETIN

8

CONTRIBUTIONS TO OCEANOGRAPHY AND FISHERIES BIOLOGY

Cape Town

1976

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WEIGHT CONVERSION FACTORS, LENGTH/WEIGHT RELATIONSHIPS AND ANNUAL LANDINGS OF SOME SOUTH AFRICAN TRAWL-CAUGHT FISH

D. S. CHALMERS

Two parameters often used in fisheries research are live catch weight and fish length/weight relationships. As most of the demersal fish landed commercially in South Africa have already been partially cleaned, the declared landed weights must be converted to live weights by applying suitable conversion factors. In this report such conversion factors are determined for the following important South African trawled fish species:

(i) Cape hakes *(Merluccius capensis* and *M. paradoxus)*
(ii) kingklip *(Genypterus capensis)*
(iii) Agulhas sole *(Austroglossus pectoralis)*
(iv) West Coast sole *(A. microlepis)*
(v) kabeljou *(Johnius hololepidotus)*
(vi) gurnard *(Trigla capensis)*
(vii) white stumpnose *(Rhabdosargus globiceps)*
(viii) monk *(Lophius piscatorius)*

Hake and kingklip are commercially landed in a headed and gutted state but the others, except monk, in a gutted condition only. In the case of monk the landed weight refers to tail weight only.

While collecting data for determining conversion factors, information was also obtained for calculating length/weight relationships for the first six of the above species.

Samples of whole fish were acquired either from commercial trawlers by special arrangement or from the research vessel *Africana II*. From weighings made on board ship, only those of kabeljou (individual weights) and white stumpnose (bulk weights) were reliable, as the sea was usually too rough to allow sufficient accuracy. For this reason, most samples from the research vessel were brought back in a whole, frozen state and weighed and measured ashore after thawing, while samples obtained from commercial trawlers were chilled on ice.

The total length of each fish was measured to the nearest centimetre below and the weight before and after cleaning noted. All gutting of the fish was carried out by hand. Monk tails were cut off with a circular saw while some hake and kingklip were put through commercial heading machines. The rest of the hake and kingklip were headed by hand.

WEIGHT CONVERSION FACTORS

The conversion factor for each species was calculated as the ratio of total whole weight to total cleaned weight in each sample. Table I reflects the conversion factors calculated, together with other relevant data concerning sources, length ranges and sample sizes for all species studied except hake and kingklip. These two species were treated separately because the weight loss due to cleaning depends upon the method used for heading; conversion factors, sources, length ranges and sample sizes for hake and kingklip are shown in Table II.

The use of a circular saw to head some selected hake and kingklip was necessary because the heading machine employed was limited in the length of fish it could accept. A small difference was noted between the conversion factors derived from the various heading techniques; different results were also noted when different per-

TABLE I: DETAILS OF SAMPLES USED IN DETERMINING WEIGHT CONVERSION FACTORS FOR SIX SPECIES

Species	Source of fish sample	Area from which obtained	Date	Degree of cleaning	How weight recorded	Sample size (no.)	Length range (cm)	Mean weight loss (%)	Range weight loss (%)	Conversion factors
Agulhas sole	Research	S.E. Coast	Aug. 71	gutted	individual	70	25–40	3,79	1,0– 9,1	1,04
West Coast sole	Commercial	Walvis Bay	Nov. 71	gutted	individual	100	36–55	5,57	2,2–10,5	1,06
Kabeljou	Research	Cape Town	Aug. 71	gutted	individual	40	35–90	13,77	4,2–30,0	1,15
Gurnard spp.	Commercial	Cape Town	Mar. 71	gutted	bulk	145	30–45	13,29	8,7–18,4	1,15 } 1,17
	Research	Cape Town	Jan. 72	gutted	individual	68	26–47	15,09	7,6–27,7	1,19 }
White stumpnose	Research	Cape Town	Apr. 71	gutted	bulk	92	30–45	9,91	7,2–14,3	1,11
Monk	Commercial	Cape Town	May 71	tails only	bulk	86	35–75	70,40	67,3–74,0	3,44

TABLE II: DETAILS OF HAKE AND KINGKLIP SAMPLES USED IN DETERMINING WEIGHT CONVERSION FACTORS

Species	Source of fish sample	Area from which obtained	Date	Degree of cleaning	How weight recorded	How handled	Sample size (no.)	Length range (cm)	Mean weight loss (%)	Range weight loss (%)	Conversion factors	
Hake spp.	Commercial	Cape Town	May 1971	headed & gutted	bulk	machine	640	30–75	31,81	27,8–35,9	1,47	1,46
	Commercial	Cape Town	May 1971	headed & gutted	bulk	circular saw	210	30–75	30,62	27,4–33,7	1,45	
	Commercial	Cape Town	June 1972	headed & gutted	individual	machine	214	34–89	35,05	18,1–57,1	1,58	
	Commercial	Cape Town	May 1972	headed & gutted	individual	hand	127	38–71	27,06	20,2–37,2	1,37	
	Research	Cape Town	Jan. 1972	headed & gutted	individual	hand	133	24–80	26,49	22,5–35,9	1,43	
Kingklip	Commercial	Cape Town	May 1971	headed & gutted	bulk	circular saw	159	45–95	31,58	24,9–35,9	1,46	1,52
	Commercial	Cape Town	May 1972	headed & gutted	individual	circular saw	268	45–112	35,74	17,0–49,9	1,57	
	Commercial	Cape Town	Mar. 1971	headed & gutted	bulk	hand	83	35–74	26,19	22,7–31,0	1,49	
	Commercial	Walvis Bay	Nov. 1971	headed & gutted	individual	hand	99	43–67	33,71	28,7–39,8	1,51	

sonnel cut off the heads or operated the heading machine. However, since these differences were small, a single conversion factor was calculated for each species by using the totals of the cleaned and whole weights from all fish, regardless of the method of cleaning adopted. The conversion factors thus calculated were 1,46 for hake and 1,52 for kingklip. At the present time (1973) 41 per cent of the kingklip and 54 per cent of the hake landed commercially are headed by hand, a fact which further justifies the combination of the various sets of data.

A linear regression of percentage weight loss due to cleaning against total fish length was plotted for all fish species except white stumpnose and monk, where individual weights were unavailable. The slopes of the lines were significant at the 1 per cent probability level in each case, indicating a difference in the percentage of weight lost between small and large fish. Over the length range used (see Tables I and II), however, this difference was small (2 – 4 per cent from the mean) so that a single conversion factor for each species was accepted.

A comparison is given hereunder between some of the conversion factors calculated in this report and those of similar species recorded from other parts of the world (F.A.O. 1970):

Hake spp.	1,46 (South Africa)	1,40 (Norway)	1,67 (Poland)
Gurnard spp.	1,17 (South Africa)	1,12 (U.K.)	
Monk sp.	3,44 (South Africa)	2,00 (Belgium)	4,35 (Poland)

On account of variations in biological factors such as the availability of food and the state of maturity of the fish and also owing to variations in the cleaning process, it is to be expected that the conversion factor for a given species would be subject to variation between different areas. This variation is particularly evident in the case of monk, where a different cleaning technique is probably the main cause of the noticeable difference.

SOUTH AFRICAN DEMERSAL FISH LANDINGS, 1917–1974

Official catch figures of trawled species caught by the South African fleet are published in the Annual Reports of the Director of Sea Fisheries. These figures refer to landed (cleaned) weights. The landed weights of selected species caught from 1917–1974 have been converted to live weight by means of the conversion factors obtained from the present study, and these weights are reflected in Table III. Monk is excluded since this species has only recently been recorded as a separate category. The catches of

TABLE III: NOMINAL CATCHES (LIVE WEIGHT) OF SELECTED SOUTH AFRICAN DEMERSAL SPECIES, 1917 – 1974, IN THOUSANDS OF METRIC TONS

Year	Hake spp.	Kingklip	Soles	Kabeljou	Gurnard spp.	White stumpnose
1917	0,7	—	—	2,1	—	0,4
1918	0,8	—	—	2,0	—	0,1
1919	1,4	—	—	1,3	—	—
1920	—	—	—	—	—	—
1921	0,9	—	—	0,7	—	0,1
1922	0,7	—	—	0,9	—	0,2
1923	1,8	—	—	0,8	—	0,5
1924	1,1	—	—	1,0	—	0,2
1925	1,4	—	—	1,5	—	0,6
1926	1,0	—	—	1,5	—	0,5
1927	0,6	—	—	1,4	—	0,3
1928	1,9	—	—	1,4	—	0,3
1929	2,7	—	—	0,9	—	0,3
1930	3,2	—	—	1,4	—	0,3
1931	2,0	—	—	0,9	—	0,3
1932	10,3	0,6	0,8	1,7	—	0,4
1933	8,0	0,4	0,8	0,9	—	0,0
1934	9,9	0,4	0,9	1,2	—	0,0
1935	10,8	0,7	1,0	1,0	—	0,0
1936	12,7	0,7	1,2	1,4	—	0,0
1937	14,5	0,7	1,1	1,3	—	0,2*
1938	15,2	0,7	1,3	1,5	—	0,1*
1939	14,4	0,7	1,2	1,4	—	0,1*
1940	20,6	0,7	0,8	1,3	—	—
1941	22,0	0,6	1,0	0,9	—	0,1*
1942	24,8	0,6	1,0	0,9	—	0,1*
1943	27,3	0,6	0,9	0,8	—	0,0*
1944	24,5	0,6	0,7	0,6	—	0,1*
1945	21,0	1,3	3,3	0,6	—	0,0*
1946	29,1	1,0	2,6	0,7	0,1	0,0*
1947	29,8	1,1	2,3	0,6	x	0,0*
1948	42,3	1,5	2,0	0,8	x	0,0*
1949	41,3	1,8	1,8	1,0	x	0,0*
1950	51,8	1,9	2,0	0,8	x	0,0*
1951	64,4	2,4	1,5	0,7	x	0,0*
1952	63,9	2,8	1,5	0,5	x	0,1*
1953	67,3	2,7	1,5	0,8	x	0,0
1954	75,8	2,0	1,4	0,5	x	0,0
1955	80,2	2,3	1,2	0,6	x	0,0
1956	82,1	2,0	1,4	0,7	0,1	0,0
1957	87,7	1,5	1,2	0,6	0,1	0,0
1958	90,8	1,7	1,2	0,6	x	0,1*
1959	100,8	2,0	0,7	0,6	0,3	0,0*
1960	111,1	1,5	1,0	0,6	0,3	0,0*
1961	103,3	2,1	2,1	0,4	0,4	0,0*
1962	102,3	1,7	1,0	0,5	0,4	0,0
1963	98,9	1,8	2,0	0,3	0,4	0,0
1964	102,2	1,4	1,9	0,4	0,2	0,0
1965	99,6	2,5	2,0	0,5	0,2	0,0
1966	124,4	3,7	2,3	0,6	0,2	0,0
1967	118,7	3,2	1,2	0,8	0,2	0,0
1968	118,6	2,9	0,8	0,5	0,5	0,0
1969	104,3	2,9	1,0	0,5	0,5	0,0
1970	96,0	2,9	1,1	0,5	0,5	0,0
1971	111,5	4,9	1,6	1,5	0,5	0,0
1972	118,1	5,2	2,7	1,0	0,4	0,0
1973	133,0	5,8	3,1	1,1	0,3	0,0
1974	134,9	3,6	1,6	0,8	0,3	0,0

— no data available
* white and red stumpnose combined
x combined with other species
0,0 greater than zero but less than 0,05 thousand metric tons

Agulhas and West Coast soles have been combined and a conversion factor of 1,05 (the mean of the two species) was used; only in recent years have the landings of these species been recorded separately. It is to be hoped that Table III will provide a useful historical record of some important South African demersal fish catches.

LENGTH/WEIGHT RELATIONSHIPS

For those species where individual lengths and weights were recorded, the length/weight relationship in each case was expressed as a regression curve $W = aL^b$ (where W = weight in g, L = total fish length to tip of the tail in cm, and a and b are constants). The equations for the regressions of whole weight on fish length and cleaned weight on fish length for hake, kingklip, Agulhas sole, West Coast sole, kabeljou and gurnard are shown in Table IV.

TABLE IV: LENGTH/WEIGHT RELATIONSHIPS OF SIX IMPORTANT SOUTH AFRICAN DEMERSAL SPECIES

Species	Whole weight/length	Cleaned weight/length
Hake spp.	$W = 0{,}00624\ L^{3.03096}$	$W = 0{,}00583\ L^{2.95462}$
Kingklip	$W = 0{,}00080\ L^{3.41974}$	$W = 0{,}00139\ L^{3.17815}$
Agulhas sole	$W = 0{,}00347\ L^{3.15382}$	$W = 0{,}00441\ L^{3.07632}$
West Coast sole	$W = 0{,}00390\ L^{3.11874}$	$W = 0{,}00491\ L^{3.04305}$
Kabeljou	$W = 0{,}01312\ L^{2.92688}$	$W = 0{,}00743\ L^{3.03240}$
Gurnard spp.	$W = 0{,}03470\ L^{2.67778}$	$W = 0{,}05462\ L^{2.50868}$

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1976

A COMPARISON OF THE EFFICIENCY OF ESCAPE GAPS AND DECK GRID SORTERS FOR THE SELECTION OF LEGAL-SIZED ROCK LOBSTERS *JASUS LALANDII*

H. B. CROUS

The Cape rock lobster is caught in depths ranging from shallow rocky pools to approximately 40 fathoms along the western coast of South and South West Africa. Since 1963, in spite of an increase in fishing effort (larger boats, more efficient traps), production has fallen and the quota was gradually reduced until the 1970/71 season when the catch was 1,591 metric tons.

On the commercial fishing grounds large numbers of rock lobsters below the minimum legal size are caught. Test fishing during the course of this investigation (Tables II and III) showed that more than 50 per cent of the catch in commercial fishing areas consisted of rock lobsters below the minimum size limit (8,9 cm carapace length). Throughout the years the fishing method has been such that large numbers of undersized rock lobsters have been brought to the surface, handled and measured before being returned to the sea.

Figure 1a illustrates the size composition in two sanctuary areas, Robben Island and the Cape Town/Hout Bay sanctuary, where the modal size occurs at 8,5 cm (immediately below the minimum size limit). Similar data, presented in Figure 1b for two important fishing grounds (Dassen Island and Cape Peninsula) show the modal size occurring at 7,5 cm. Assuming that recruitment, growth and natural mortality rates are similar in each of these areas, the lower modal size of the exploited populations suggests that although rock lobsters in the 8,5–8,9 cm size class (i.e. following season's recruitment) are not landed, fishing activity may be the cause of mortalities in this size class. A large measure of this mortality may be attributed to the present methods of sorting the catch. Rock lobsters well below the minimum size limit are immediately returned to the sea, while the marginally sub-legal rock lobsters are individually measured. The time required to sort and measure these rock lobsters could cause mortality due to exposure and damage through handling.

Two methods of possibly reducing the mortality of undersized rock lobsters were investigated. Firstly, traps fitted with specially designed escape gaps allowing only rock lobsters below the minimum legal size to pass through, were tested.

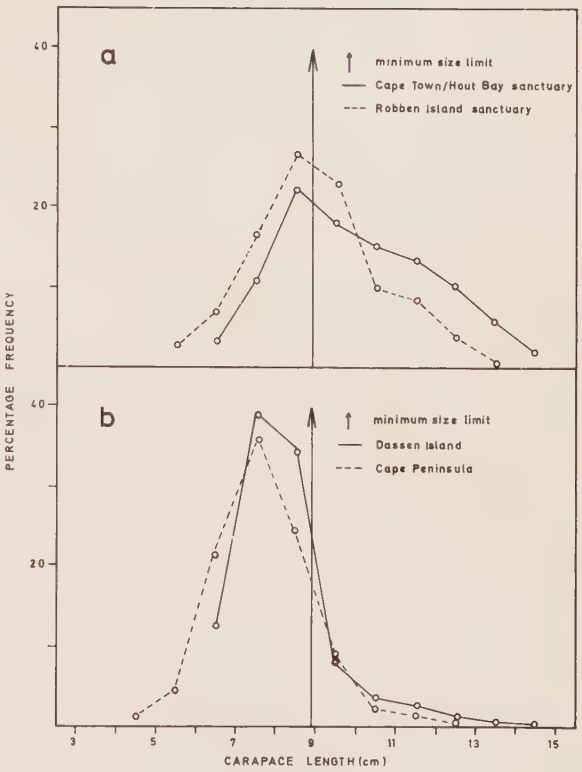

FIG. 1: SIZE COMPOSITION OF THE CATCH IN: (*a*) SANCTUARIES, (*b*) COMMERCIAL GROUNDS

Secondly, the performance of a deck grid sorter was tested. The rates of escape of sub-legal rock lobsters from both types of gear are compared in this report.

METHODS

Experimental fishing was carried out on the heavily exploited commercial grounds off the

FIG. 2: ROCK-LOBSTER TRAPS: (*a*) STANDARD, (*b*) ESCAPE-GAP TRAP TYPE 1, (*c*) ESCAPE-GAP TRAP TYPE 2, (*d*) ESCAPE-GAP TRAP TYPE 3

Cape Peninsula and Dassen Island. Similar tests were also conducted in the Cape Town/Hout Bay rock lobster sanctuary to determine whether size composition affected the rate of escape.

Fishing operations were carried out from the Sea Fisheries Branch's research vessels and a commercial fishing boat. The longline trap-fishing method was used on board R.S. *Sardinops*. Ten traps were set per longline, five of which were fitted with escape gaps and five of which were standard rectangular traps. The traps were arranged so that each standard trap alternated with an experimental one.

The fishing method employed on board the R.V. *Trachurus, Kunene* and the commercial boat differed slightly from that described for R.S. *Sardinops* in that, instead of a longline, ten single traps were set in the same order as described above. In both cases the traps were hauled after three hours.

The standard trap used on both commercial grounds has a mild-steel bar frame with the following dimensions: 135 cm × 86 cm × 53 cm. The framework is covered with polyethylene netting of 6,2 cm stretched mesh. The netting is extended beyond the frame at the bottom end of the trap to form a bag. The trap, illustrated in Figure 2a, is emptied by simply loosening the slipknot in the bag.

The escape-gap traps were of similar design with a 5,1 cm spaced mild-steel bar grid replacing the bag at the bottom end of the trap. For the purpose of this experiment a coverbag of small mesh (3,1 cm) netting was attached to the trap to ensure that all the rock lobsters escaping through the grid would be collected. The percentage of rock lobsters which would have escaped could thus be calculated for each area investigated.

The design of escape-gap traps presented two main problems: firstly, an optimum gap size had to be established and secondly, removal of the catch had to be facilitated. Two sets of data were used for the selection of a suitable gap size. A plot of carapace depth on length (Fig. 3) indicated that rock lobsters with a carapace length less than 8,9 cm (the present size limit) would normally escape through a gap of 5,6 cm. This was tested by passing rock lobsters through a wooden grader with gaps of 4,4, 4,8 and 5,1 cm respectively. The aforementioned method was used by Bowen (1963) for testing the effectiveness of escape gaps in traps for *Panulirus cygnus*.

To overcome the problem of easy removal of the catch from escape-gap traps, three different trap designs were tested. The first (Type 1) was a rectangular trap with escape gaps fitted to the bottom (Fig. 2b). To remove the catch a door was fitted on the one side of the trap. Type 2, as illustrated in Figure 2c, was of similar design with a bag on the side replacing the door. The Type 3 design had no door or side-bag and differed in the construction of the grid in that it consisted of two halves, hinged at opposite ends and locked into position by means of a steel rod sliding into a channel. This design is illustrated in Figure 2d.

The alternative to escape gaps, i.e. rapid sorting of rock lobsters on board, was investigated using the apparatus illustrated in Figure 4. The deck grid sorter consisted of a 122cm × 92 cm grid with a 5,1 cm gap size which fitted into a wooden box with a mild-steel frame. The box was attached to the inside of the gunwale and a hole was cut through the gunwale to accommodate a tapering shute through which rock lobsters below the legal size falling through the grid could be returned to the sea. The position of the grid was about 23 cm below the rim of the box. By installing a deck grid sorter, the distance between the suspended trap and the deck was considerably reduced thereby decreasing the possibility of rock lobsters being damaged by rough handling on board.

To test the deck grid sorter, escape-gap and standard traps were baited and set. In the case of the standard traps, the catch was simply emptied into the deck sorter and the number of lobsters that escaped were counted. The catches made by escape-gap traps were treated in a slightly different manner. It was assumed that all the rock lobsters in the cover-bag would have escaped through the grid. The catch in the bag was removed and counted and the remaining rock lobsters in the trap emptied into the deck sorter. The number of rock lobsters that escaped through the grid was noted. Rock lobsters remaining on the grid were counted and measured to determine the proportion of undersized animals.

A Vernier caliper was used to measure the carapace length along the mid-dorsal line, from the tip of the rostrum to the posterior edge of the carapace.

RESULTS

The gap size for both the escape-gap traps and the deck grid sorter was established at 5,1 cm.

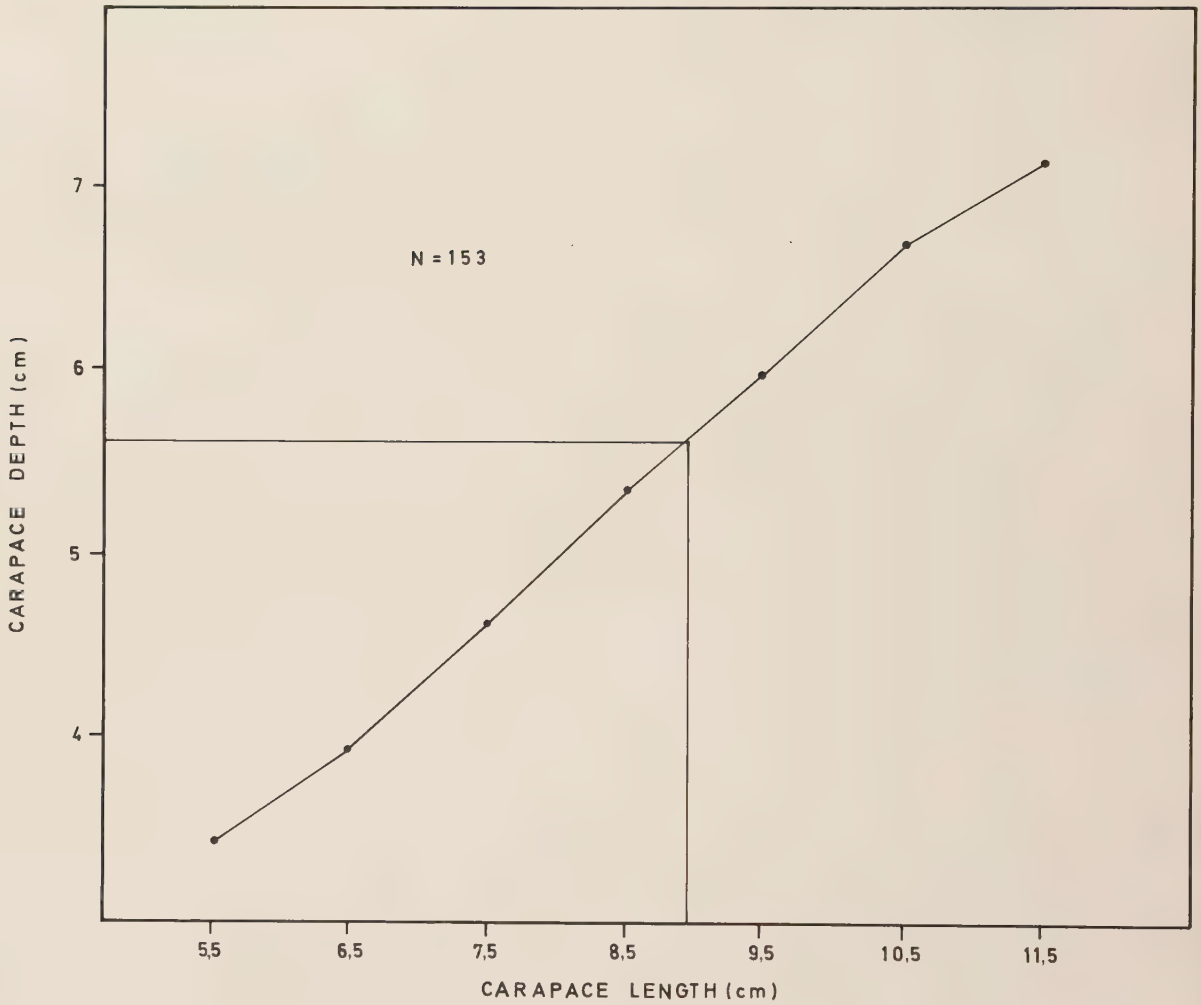

FIG. 3: RELATIONSHIP BETWEEN CARAPACE DEPTH AND LENGTH

Table I shows that this particular gap size would allow the greatest number of undersized rock lobsters to escape while ensuring that all the animals above minimum size be retained.

To evaluate escapement, the number of animals remaining in the escape-gap traps were compared with the numbers which had escaped through the grid into the cover-bags. Additionally, the catches within the escape-gap traps were compared with those of standard traps set at the same place for the same duration. Frequency escape data were calculated for the three types of escape-gap traps used at Dassen Island and are illustrated in Figure 5. Type I allowed a larger percentage of rock lobsters of all size classes below the minimum size limit to escape. Types 2 and 3 experimental traps proved to be less successful in this area; possibly the method of emptying the trap caused an obstruction to the actual escape route.

Frequency escape plots for the experimental traps used off the Cape Peninsula (illustrated in Figure 6), appear more confused than those from the Dassen Island grounds. The well-defined differences shown by the curves for Dassen Island (Fig. 5) do not appear in data from

FIG. 4: DECK GRID SORTER

TABLE I: PERCENTAGE FREQUENCY OF SIZE CLASSES OF ROCK LOBSTERS PASSING THROUGH A WOODEN GRADER WITH ASSORTED GAP SIZES

Gap (cm)	Size class (cm)						
	6,0–6,4	6,5–6,9	7,0–7,4	7,5–7,9	8,0–8,4	8,5–8,9	9,0–9,4
4,4	100	88,9	26,6	0			
4,8	100	100	68,1	51,4	0		
5,1	100	100	100	98,6	53,4	1,8	0
Sample size	3	27	94	70	58	54	21

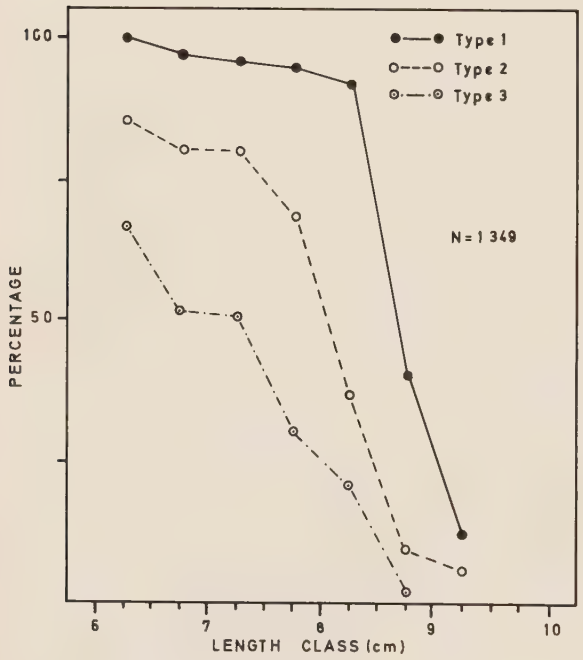

FIG. 5: PERCENTAGE ESCAPE PER SIZE CLASS – DASSEN ISLAND

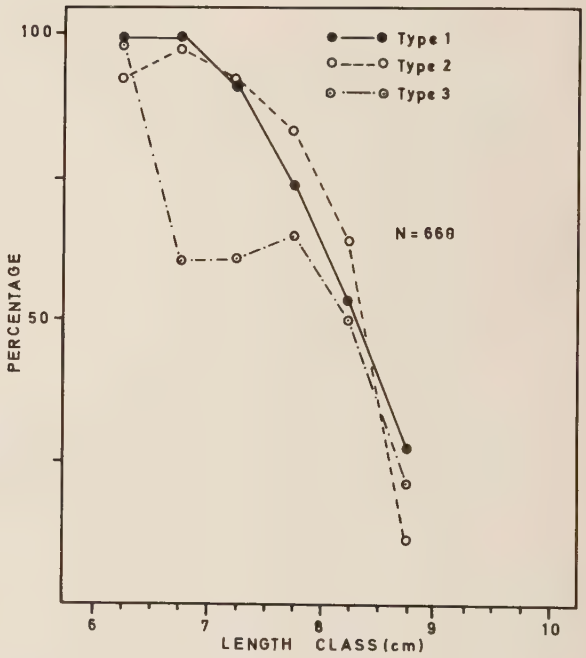

FIG. 6: PERCENTAGE ESCAPE PER SIZE CLASS – CAPE PENINSULA

the Cape Peninsula grounds. These discrepancies are difficult to understand but may be due to the average number of rock lobsters caught per trap in the two areas. At Dassen Island 99 test hauls were made, resulting in an average catch per trap haul of 26,6 rock lobsters. In comparison, a much lower catch per trap haul of 9,8 rock lobsters was made in 90 test hauls in the Cape Peninsula area. The larger average catch per haul at Dassen Island is more likely to clog the grid thereby impeding the escape of rock lobsters below legal size.

Presumably, the design of the trap becomes more critical under these conditions and traps of Type I design are more advantageous. Observations at sea proved that the designs of Types 2 and 3 experimental traps were such that the bag on the side of the trap in the case of Type 2 and the locking bar of Type 3 hindered the escape of undersized lobsters.

Test fishing in the Cape Town/Hout Bay sanctuary, where rock lobsters are generally larger

than on the commercial grounds, indicated that no particular type of experimental trap was of more effective design. Frequency-of-escape plots for all types of experimental traps, illustrated in Figure 7, show a confused pattern. The escape of the undersized rock lobsters was apparently hindered by the large proportion of legal sized animals which effectively clogged up the escape route as the traps were being raised.

A comparison of the frequency-of-escape plots for all the grounds investigated (Figs. 5, 6 and 7) indicates that, although at Dassen Island the trap design contributed towards more efficient selectivity, this was not the case in the other areas. It seems that clogging of the grid by larger rock lobsters, the numbers caught per trap and the method of emptying the catch are all factors influencing the rate of escape from the experimental traps.

Additional tests were carried out in the Cape Town/Hout Bay sanctuary and in the Cape Peninsula commercial grounds, passing rock lobster samples through a deck grid sorter. The data were obtained by using standard as well as escape-gap traps.

Results from the Cape Town/Hout Bay sanctuary (Table II) indicate a higher rate of escape through the deck grid sorter than through the experimental traps (54 per cent compared with 23 per cent).

Data obtained from experimental fishing carried out in the Cape Peninsula commercial area and presented in Table III follow a similar pattern and prove that the deck grid sorter is more efficient. In fact, the percentage of rock lobsters sorted automatically by the deck sorter in both areas in which the trials took place is approximately double that of the escape-gap traps. This is probably due to the larger surface area available for rapid automatic sorting using a deck grid sorter and, consequently, a reduced amount of interference caused by the clogging of the escape route by the larger animals.

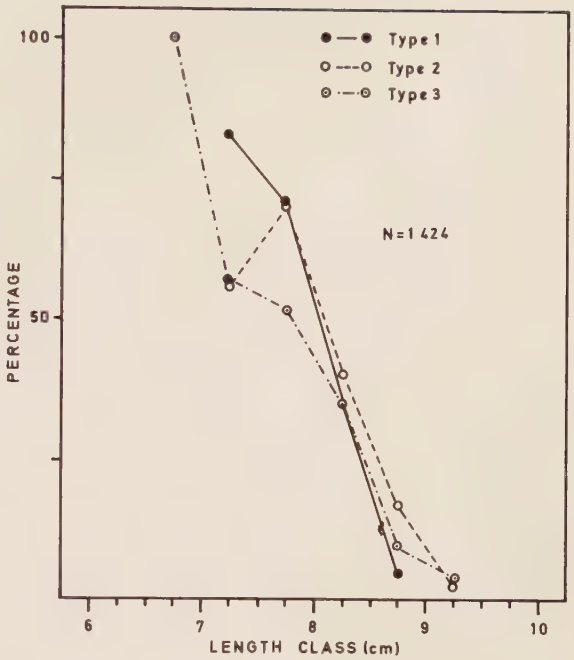

FIG. 7: PERCENTAGE ESCAPE PER SIZE CLASS— CAPE TOWN/HOUT BAY SANCTUARY

TABLE II: CAPE TOWN/HOUT BAY SANCTUARY: A COMPARISON OF THE SORTING EFFICIENCY OF ESCAPE-GAP TRAPS AND THE DECK GRID SORTER

Number	Escape-gap traps		Deck grid sorter	
	Number	Percentage	Number	Percentage
Sorted automatically	128	23	237	54
Sorted manually	417	76	203	46
Total caught	545		440	
Legal size	164	30	182	41

COMMENTS AND CONCLUSIONS

In certain areas the design of escape-gap traps appeared critical but this was not consistent.

TABLE III: CAPE PENINSULA GROUNDS: A COMPARISON OF THE SORTING EFFICIENCY OF ESCAPE-GAP TRAPS AND THE DECK GRID SORTER

Number	Escape-gap traps		Deck grid sorter	
	Number	Percentage	Number	Percentage
Sorted automatically	581	38	1 496	73
Sorted manually	953	62	548	27
Total caught	1 534		2 044	
Legal size	223	15	282	14

However, a comparison between the results obtained by using traps fitted with escape gaps and standard traps used in conjunction with a deck grid sorter showed that the latter combination was more efficient, probably because of the larger area available for sorting. The use of escape-gap traps was not advantageous, because emptying these traps required a more complicated procedure than simply releasing the slip knot on the bag attached to a standard trap.

As fishing often takes place under adverse conditions at sea, there is also the likelihood that the grids fitted to escape-gap traps could become distorted, gap sizes could change and the system would therefore become less efficient.

An additional advantage of the deck grid sorter would be the costs involved in outfitting a boat. The cost of a deck grid sorter averages out at ± R150 per unit compared to R10 per trap in the case of escape-gap traps. As most of the commercial trap-fishing boats operate with approximately 60 traps, this makes it an expensive modification compared with the deck grid sorter.

Although escape gaps do allow rock lobsters below the legal size to escape, the deck grid sorter proved to be the most efficient and economical escape mechanism available to the commercial rock-lobster fisherman.

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OBSERVATIONS ON THE POTENTIAL EXPLOITATION OF LIMPETS ALONG THE WESTERN CAPE COAST

G. DE VILLIERS

This report is based on the results of an investigation conducted on 10, 11 and 12 March 1971. The purpose of the investigation was to assess the merits of a proposal received by the Sea Fisheries Branch that limpets be exploited near the Green River mouth, along the Western Cape Coast.

At the time of the survey relatively little was known about the detailed ecology and biology of South African limpets. However, this knowledge has since been greatly expanded through recent investigations by Branch (1971, 1974a, 1974b, 1975) on limpet species which occur off the Cape Peninsula. No stock assessment has as yet been made on any South African limpet.

AREA INVESTIGATED

The Green River mouth is situated 130 km north of Lambert's Bay at latitude 30°51'S.

The proposed fishing grounds cover 100 km of coastline, i.e. 50 km on either side of the Green River mouth. Rocky shores account for approximately two-thirds of the coast in this region. The intertidal strip is generally quite wide as the beach has only a slight slope. The rocky shores consist predominantly of rough rocky laminae sloping towards the sea at an angle of ± 30°, with several rows of trench-like tidal pools running parallel to the beach between successive rocky ridges. This type of formation is interrupted every few kilometres by small bays containing round cobbles of 30–130 cm diameter offering excellent conditions for limpets.

Below the intertidal zone there is a belt of kelp interspersed with rocky outcrops. Some of these outcrops rise to a height of 2 m above the spring low-water mark.

MATERIAL AND METHODS

Some 25 km of coast line, from 16 km south to 9 km north of the Green River mouth, were casually inspected and four sites investigated in detail. Sites 1 – 4 were respectively at 8 km south, 1 km south, 2 km north and 8 km north of the mouth.

At each site a line count was made during spring low tide, covering a strip 46 cm wide between the high-water and low-water marks. Only every second 3 m section of the entire line transect was examined. Initially, a measuring gauge was employed to differentiate between limpets larger and smaller than 40 mm in shell length. Subsequent judgement was by eye and the two categories were recorded separately.

Representative samples were taken at each site from the "lower", "middle" and "higher" regions of the intertidal zone and were used for determination of the species composition, size composition and yield potential of the limpet stock. Additional large limpets were collected to provide more information for the determination of the length/total weight and length/meat weight relationships. Shell length was measured by means of a Vernier caliper to the nearest millimetre and the weight to the nearest 0,1 g using a Triple Beam balance.

RESULTS

Although several species of limpets were encountered during the survey, only three warranted consideration for the present study. These were *Patella granularis* Linn., *P. granatina* Linn., and *P. miniata* Born.

The distribution of *P. miniata* was predominantly subtidal, but a few were exposed during spring low tide, mainly on the rocky outcrops in the kelp zone. Subtidal observations indicated that the species was common in this zone, but owing to its inaccessibility from the shore, no quantitative assessment could be made. For the same reason it was concluded that this species would contribute little to a commercial fishery conducted above the low-water mark, despite its fair size and abundance.

TABLE I: SPECIES COMPOSITION OF RANDOM SAMPLES FROM THE INTERTIDAL ZONE

Species	Percentage at each site			
	1	2	3	4
P. granatina . . .	35,4	52,5	26,2	15,9
P. granularis . . .	56,0	43,8	72,9	84,1
Other species . . .	8,6	3,7	0,9	0,0
Total number of limpets at each site . . .	257	80	553	359

Within the intertidal zone *P. granularis* and *P. granatina* accounted for more than 90 per cent of all the limpets present. *P. granularis* was usually the more abundant (Table I).

There were indications that the average size of both species tended to increase from the low-water mark towards the high-water mark. This meant that the full size range of both species was easily accessible.

FIG. 1: LENGTH DISTRIBUTION OF *Patella granularis* AND *P. granatina*

Figure I shows the length distribution of *P. granularis* and *P. granatina*. Few *P. granularis* were larger than 50 mm shell length, while most were much smaller. Such small limpets may be impractical for harvesting, while permission to harvest them may also expose the larger and faster growing *P. granatina* (Branch 1974b) to detrimental exploitation. It appears clear that the smaller limpets will not be exploited. *P. granularis* is therefore unlikely to make a significant contribution to the catch.

Taking all these facts into consideration, it appears that commercial exploitation will be based mainly, if not exclusively, on *P. granatina*. In order to determine the yield potential of this stock the ratios between shell length and biomass (total weight), as well as between shell length and meat weight were established (Fig. 2). From this information as well as line-count results, estimates of biomass and meat weight were derived. These are presented in Tables II and III.

TABLE II: LINE COUNTS OF LIMPETS AT EACH SITE

Site	Transect length (m)	No. of limpets counted	
		Shell length less than 40 mm	Shell length 40 mm and more
1	54	662	410
2	31	871	41
3	51	1 316	304
4	27	460	51

Sites 1 and 3 were chosen to indicate population densities inside the cobble-filled bays, while sites 2 and 4 were representative of the exposed rocky shore.

TABLE III: BIOMASS AND MEAT WEIGHT DISTRIBUTION OF *P. granatina* AT EACH SITE

Site	*P. granatina* with shell length of 50 mm and more per m of beach		
	Number	Biomass (kg)	Meat weight (kg)
1	1 234	49,77	21,81
2	83	2,31	1,19
3	921	29,68	15,44
4	96	1,88	0,96

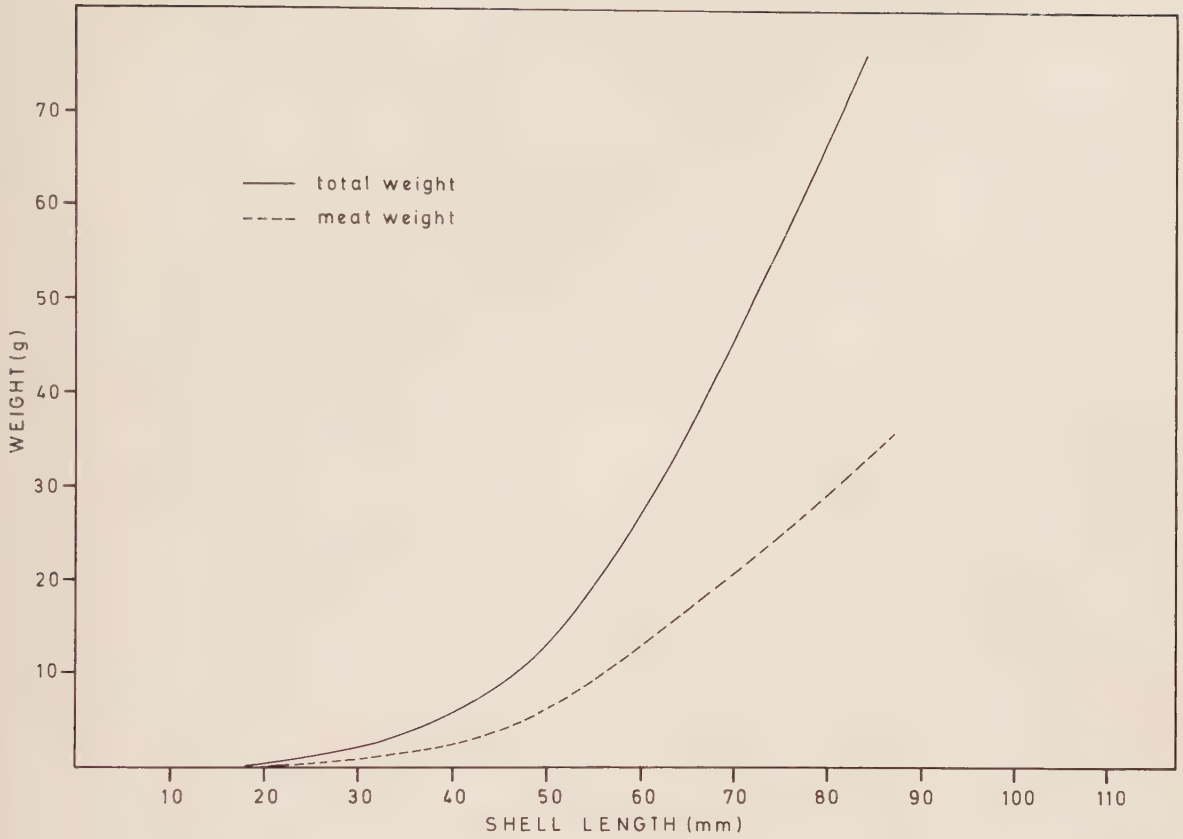

FIG. 2: LENGTH/WEIGHT RELATIONSHIP OF *Patella granatina*

DISCUSSION AND CONCLUSIONS

Owing to geographical features, it may be assumed that the figures obtained for sites 1 and 4 (Table II) are indicative of the possible range of stock densities occurring along the proposed fishing grounds. In order to calculate the standing crop available for exploitation, the following parameters must be estimated:

(i) Minimum size
(ii) Average meat weight per metre of rocky shore
(iii) Proportion of standing crop available for exploitation.

To provide factual figures for these parameters would require a more intensive study than this brief investigation has allowed. However, on the basis of past experience and from recent publications some estimates have been made.

Using the life table and growth rate presented by Branch (1974b), a year class would reach its maximum meat weight at an average shell length of 68 mm (age $\pm$ 2½ years). This represents the "critical" size or upper boundary for minimum size based on yield per recruit (Ricker 1945). Branch (1974a) stated that all *P. granatina* are sexually differentiated at a meat weight of 3 g. This apparently corresponds with a shell length of 40 mm and an age of $\pm$ 1 year. It is probable that the optimum minimum size in a limpet fishery will fall somewhere between these two extremes, e.g. 50 mm shell length.

As approximately 90–95 per cent of the area inspected was of the exposed rocky formation type, it was logical to assume an overall average meat weight distribution for *P. granatina* with a

shell length of 50 mm and more, of closer to that for sites 2 and 4 (Table III), i.e. about 2,0 kg/m.

From these assumptions, the standing crop (in metric tons) in terms of meat weight for the 100 km stretch of coast, compensating for sandy beaches, may be calculated as follows:

$$\text{Standing crop} = \frac{(\text{length of rocky coastline in m}) \times (\text{meat weight distribution in kg/m})}{1\,000}$$

$$= \frac{(\frac{2}{3} \times 100\,000) \times 2}{1\,000}$$

$$= 133 \text{ metric tons}$$

To estimate the proportion of the standing crop available for exploitation is extremely difficult, as this proportion depends *inter alia* on unknown parameters such as recruitment rate. It is likely that a figure of 5 to 10 per cent per year is conservative. This assumption indicates an annual yield of between 6 and 13 metric tons (meat weight). This would be rather little for commercial purposes, especially when one considers that exploitation should take place evenly throughout the fishing grounds, as these animals cannot migrate extensively.

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GILL ARCH MORPHOLOGY OF THE CAPE HAKES *MERLUCCIUS CAPENSIS* CAST. AND *M. PARADOXUS* FRANCA

K. L. M. BENTZ

During a recent study of the comparative feeding behaviour of the Cape hakes, *Merluccius capensis* Cast. and *M. paradoxus* Franca, by Botha (Sea Fisheries Branch, personal communication), it was found that, while the diets of these two closely related species are generally similar, the change from a mainly planktivorous to a mainly piscivorous diet takes place at a greater fish length in *M. paradoxus* (approx. 50 cm) than in *M. capensis* (approx. 40 cm).

The reason for this change in diet was not apparent from the feeding study, but as it is well known that gill raker structure and number are closely related to diet (Scofield 1934, Yasuda 1960, Ommanney 1965, Shen 1970, Magnusen and Heitz 1971, King and Macleod in press), it was decided that an investigation of the gill structure of the two species, particularly of the gill rakers, be made.

Fish that feed on the smallest of plankton, such as some members of the shad family (*Alosa* sp.), possess numerous, well-developed rakers, with additional branches that form a strainer comparable to the finest muslin (Ommanney 1965). In other fish, e.g. perch *(Perca fluviatilis)*, the gill rakers are undeveloped and are represented only as small knobs or processes. Such fish cannot feed on plankton as they are unable to retain small prey (Ommanney op. cit.). The shape and the number of gill rakers may change with the growth and development of the fish, e.g. in the pilchard *(Sardinops ocellata)* and anchovy *(Engraulis capensis)*, where food preference alters during the life-cycle (King and Macleod in press).

In this report, the gill arches of the two closely related species of Cape hake are considered. Special attention is paid to the comparative structure and function of the gill rakers and their influence on feeding behaviour.

MATERIAL AND METHODS

Samples of hake were obtained from trawls made off the west coast of South Africa by the R.S. *Africana II* during 1973. Small specimens of *M. capensis* (under 10 cm total length) were caught in Table Bay. The smallest *M. paradoxus* examined was 16 cm long.

The species were identified by examining the pigmented areas on the tubercles according to the method of Van Eck (1969). Fish were subsequently grouped into 10 cm length classes and a random sample was taken from each.

Gill raker measurements were taken from 237 specimens, 129 *M. capensis* and 108 *M. paradoxus*. The left outer gill arches were dissected from freshly thawed specimens and the epibranchial and ceratobranchial stretched until the rakers were stiffly erect in parallel rows. Thus extended, the arch was pinned out for observation and measurement under a dissecting microscope. An ocular micrometer was used to measure the gaps at the base of adjacent rakers (Fig. 1) and the raker lengths of smaller specimens. The lengths of the epi- and ceratobranchials and all the raker lengths of the larger specimens were measured to the nearest 0,1 mm by means of a Vernier caliper.

The mean raker gap and mean raker length were determined separately for each of the epibranchial and ceratobranchial components and also for the combined epi- and ceratobranchial of each specimen. The filtering area was calculated as the product of the length of the combined epi- and ceratobranchial of the arch and the average gill raker length.

THE GILL ARCH

Morphology

In Cape hakes, the inner faces of both inner and outer gill arches have knob-like gill tubercles covered with short spiny projections (Fig. 1). The gill rakers are attached to the upper outer face of the outer gill arches only and embody lateral spiny processes (Fig. 1 inset). The

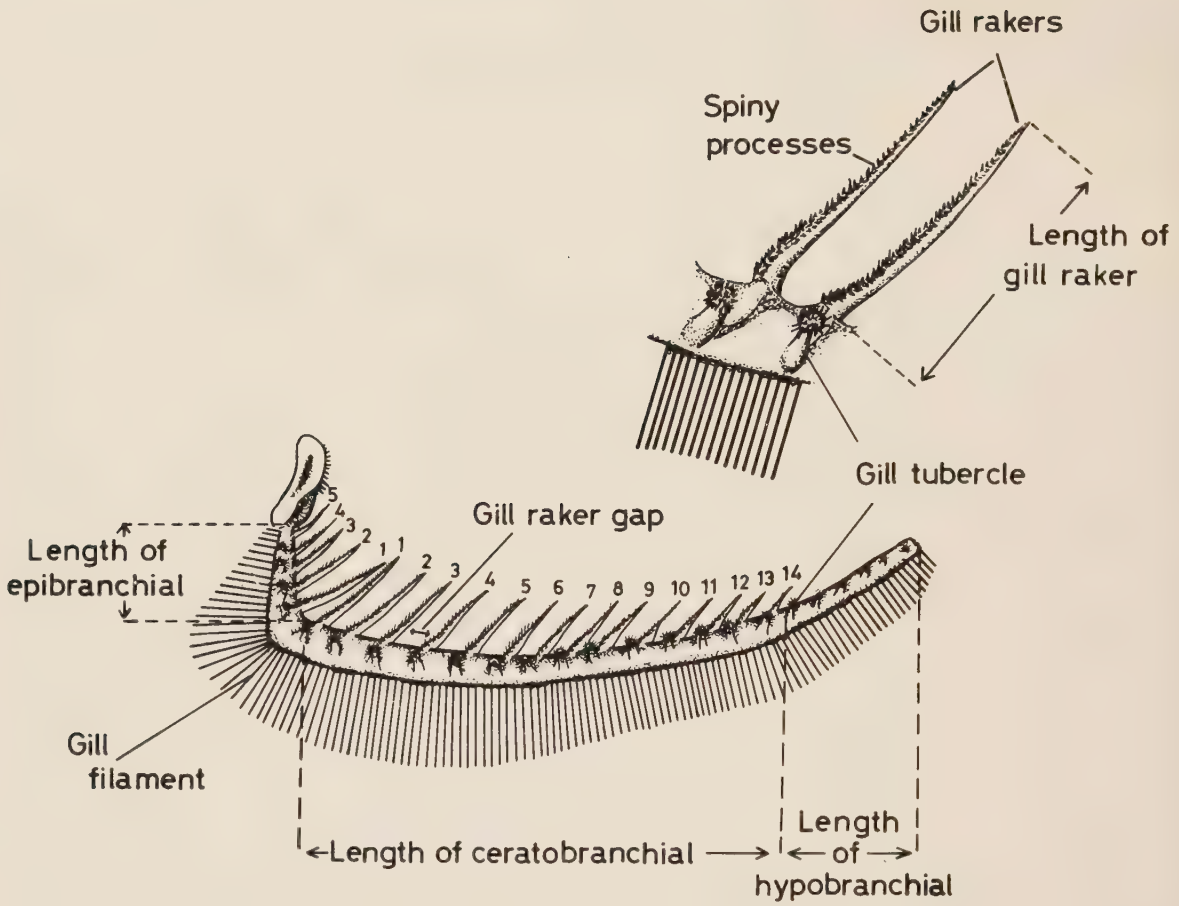

FIG. 1: STRUCTURE OF A TYPICAL OUTER GILL ARCH OF THE CAPE HAKE AND MANNER OF MEASUREMENT (INSET: GILL RAKERS SHOWING ROWS OF SPINY PROCESSES)

longest rakers are situated at the joint between the epi- and ceratobranchials, the rakers becoming progressively shorter towards the ends of the arch. Generally, the widest gap between rakers is found at the joint of the epibranchial and the ceratobranchial.

Gill raker comparisons

No relationship could be found between the number of rakers and the length of the fish for either species in the samples examined (see Table I). It is thus apparent that the Cape hakes have developed their full complement of rakers at an early age (at a length of at most 4,4 cm for *M. capensis* and at most 16 cm for *M. paradoxus*) and that this number of rakers subsequently remains constant throughout life. No ramification of the processes on the rakers was noted in larger fish.

Table II compares the number of rakers on the epibranchials and ceratobranchials of the two species. A wide variation and a marked difference even within species and sex of fish are noticeable, thus indicating that gill raker count cannot in this instance be used as a taxonomic feature. This evidence supplements the findings of Van Eck (1969) who also demonstrated an excessive overlap in gill raker count.

Table III shows the frequency distribution of the total gill raker count for each species ob-

TABLE I: GILL RAKER NUMBER AT DIFFERENT LENGTHS

Fish length (cm)	Number of rakers		
	Epibranchial	Cerato-branchial	Total
	M. capensis		
4,4	5	14	19
8	4	12	16
8	4	13	17
8	5	12	17
14	6	14	20
14	4	13	17
30	4	12	16
30	4	13	17
37	4	12	16
37	5	15	20
41	5	13	18
41	6	16	22
46	4	11	15
79	4	12	16
95	4	15	19
	M. paradoxus		
16	6	16	22
20	7	16	23
20	3	13	16
25	5	16	21
35	5	16	21
35	6	16	22
36	5	13	18
41	7	15	22
46	7	14	21
46	5	16	21
57	6	18	24
59	4	13	17
62	7	17	24
83	4	12	16
90	5	15	20

tained during the present study and during an earlier study by Jones and Mackie (1970).

Student's "t" test was applied to test the significance of the difference between the species on the basis of gill raker count. The probability of exceeding the observed value of "t" was much smaller than 0,001 (t = 13,8568; d.f. = 235) and the difference is thus highly significant. This confirms the findings of Jones and Mackie (op. cit.).

TABLE III: FREQUENCY DISTRIBUTION OF TOTAL GILL RAKER COUNT FOR EACH SPECIES

Number of gill rakers	Frequency			
	M. capensis		*M. paradoxus*	
	Jones and Mackie	Present study	Jones and Mackie	Present study
15		3		
16		18		2
17	6	32		1
18	10	41	1	7
19	11	30	8	27
20	6	3	12	27
21	2	1	9	30
22		1	4	10
23			2	2
24				2
Sample size	35	129	36	108
Mean	18,66	17,7	20,36	20,1
Variance	1,291	1,4769	1,437	2,0062

Morphometric differences in the gill arch structure

The gill raker apparatus consists of two parts, the gill arch and the gill rakers. The product of the extended length of the whole arch and the mean length of the rakers represents the area for filtering food.

The relationship between gill arch length and fish length for each species may be expressed by an equation of the form $y = ax + b$ (see Table IV). Thus, it is evident that for both species the gill arch length is directly proportional to the fish length.

It would further be expected that the raker length is an important variable determining the difference in filtering area. When the mean

TABLE II: RANGE IN THE NUMBER OF GILL RAKERS

Arch	Number of rakers							
	M. capensis				*M. paradoxus*			
	Males	Females	Combined males and females	Mode	Males	Females	Combined males and females	Mode
Epibranchial	4–6	3–6	3–6	4	3–7	4–7	3–7	6
Ceratobranchial	12–15	11–16	11–16	13	13–16	12–18	12–18	14
Combined epi- and ceratobranchial	16–20	15–22	15–22	18	16–22	16–24	16–24	21

TABLE IV: RELATIONSHIP BETWEEN GILL ARCH LENGTH AND FISH LENGTH FOR EACH SPECIES

Species	Linear relationship	Correlation coefficient (r)
M. capensis	$y = 0{,}10x + 0{,}523$	0,991
M. paradoxus	$y = 0{,}10x + 0{,}662$	0,982

x = fish length y = gill arch length

raker length was regressed against total fish length the resulting curves (of the form $y = ax^b$) indicated an initial rapid growth rate of rakers slowing down as the fish increased in length (Fig. 2).

In *M. capensis* the rakers grow more slowly than in *M. paradoxus*. For example, a *M. capensis* of 40 cm and a *M. paradoxus* of 36,5 cm have the same mean raker length (8 mm) and a *M. capensis* of 55 cm and a *M. paradoxus* of 50 cm both have an average raker length of 10 mm.

As the mean raker length increases more slowly in *M. capensis* than in *M. paradoxus*, the corollary is that the mean filtering area will also increase more slowly. Curves illustrating this are shown in Figure 3.

Since the gap between rakers would be an important factor in determining the mesh size and therefore the filtering efficiency of the gill raker device, the relationship between the raker gap and the total fish length was also considered. The corresponding regression lines are shown in Figure 4. A difference between species is evident, the slope for *M. capensis* being steeper than that for *M. paradoxus*. Hence, for the length ranges investigated, the mean gap between

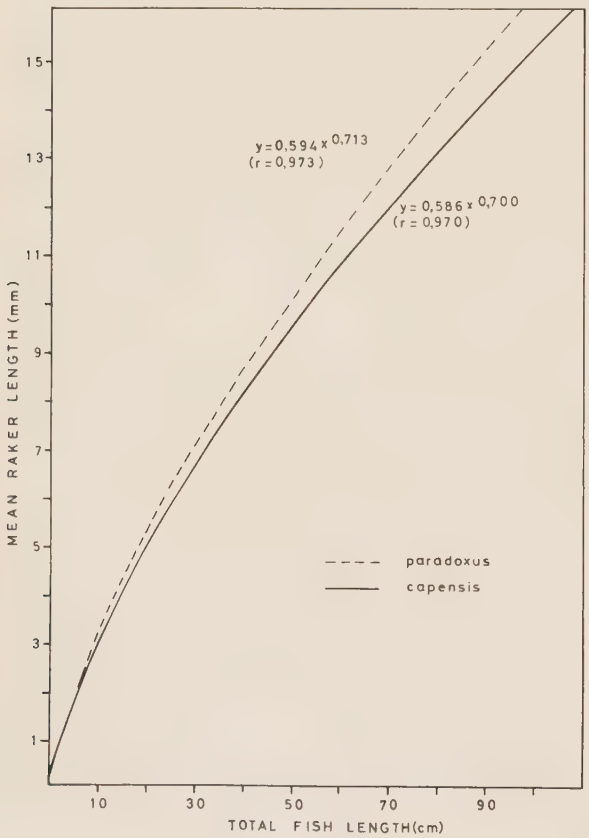

FIG. 2: RELATIONSHIP BETWEEN FISH LENGTH AND MEAN RAKER LENGTH FOR EACH SPECIES

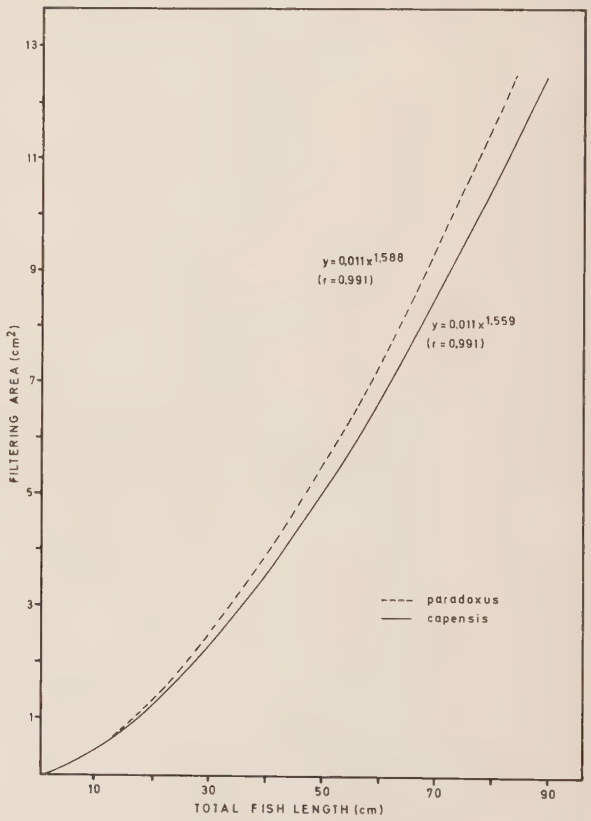

FIG. 3: RELATIONSHIP BETWEEN FISH LENGTH AND MEAN FILTERING AREA FOR EACH SPECIES

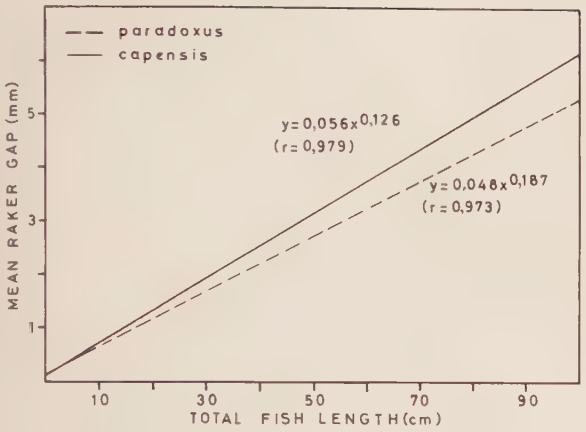

FIG. 4: RELATIONSHIP BETWEEN FISH LENGTH AND MEAN RAKER GAP FOR EACH SPECIES

rakers increased more rapidly with the length of fish in *M. capensis* than in *M. paradoxus*. Magnuson and Heitz (1971) showed that the selectivity of the gill raker apparatus varied with the gill raker gap and that a fish with a smaller gap, regardless of species or length, could be expected to be more planktivorous.

The data from five selected specimens covering a wide length range is listed in Table V. It is evident that *M. paradoxus* has longer rakers and a smaller gap than *M. capensis* individuals of the same length. *M. paradoxus* individuals would therefore be expected to be more efficiently zooplanktivorous at a greater length. *M. capensis* individuals, with their shorter rakers and larger gap, have a smaller, coarser filtering area and would be expected to become piscivorous sooner.

TABLE V: A COMPARISON OF MEAN RAKER LENGTHS AND MEAN RAKER GAPS OF *M. capensis* AND *M. paradoxus* AT SELECTED LENGTHS

Fish length (cm)	Mean raker length (mm)		Mean raker gap (mm)	
	M. capensis	*M. paradoxus*	*M. capensis*	*M. paradoxus*
20	4,9	5,2	1,3	1,2
30	6,5	6,9	1,9	1,7
40	8,0	8,6	2,6	2,2
50	9,4	10,0	3,2	2,7
60	10,6	11,4	3,8	3,3

CONCLUSION

Botha (personal communication) showed that, at approximately 40 cm total fish length, the diet of *M. capensis* changes from amphipods, euphausiids and a low percentage of myctophids to a virtually exclusively piscivorous diet of predominantly small hake. In *M. paradoxus* the change from a zooplanktivorous to a piscivorous diet occurs at a fish length of approximately 50 cm. Figure 2 shows that a *M. capensis* of 43 cm length and a *M. paradoxus* of 49 cm have the same raker length (9 mm). Figure 4 indicates that a *M. capensis* of 43 cm length and a *M. paradoxus* of 50 cm have a similar gap between rakers (2,7 mm). Hence, it appears that when the raker length reaches ± 9 mm and the gap between gill rakers reaches ± 2,7 mm the gills become inefficient for zooplankton filtering and a change in feeding habit takes place.

It is clear that feeding habits and gill structures are closely related and that for *M. capensis* and *M. paradoxus* the efficiency of the filtering apparatus does not increase with fish size. The gill rakers develop no further processes and, owing to an increase in the gap between rakers, the mesh size of the filtering area becomes more coarse and therefore less efficient. This sets a limit on the ability to retain smaller prey so that larger prey is taken as the individuals grow.

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INCIDENTAL COLLECTIONS OF SMALL AND JUVENILE FISHES FROM EGG AND LARVAL SURVEYS OFF SOUTH WEST AFRICA (1972 – 1974)

M. J. O'TOOLE

The South West African Pelagic Egg and Larval Survey (SWAPELS) was commenced by the Sea Fisheries Branch in 1972 as part of the Cape Cross Research Programme (Cram and Visser 1972). The collections were made primarily to study the seasonal distribution and relative abundance of eggs and larvae of commercial pelagic species in the upper 50m layer between latitudes 18°20′S (Cape Frio) and 24°40′S (Hollams Bird Island).

A dense sampling grid, consisting of twenty lines with nine stations on each line (Fig. 1) was sampled monthly from August 1972 to March 1973 and from August 1973 to April 1974. The periods August to April were specifically selected to coincide with the known main spawning months of the commercially important pelagic species. The inshore station of each line was approximately 8 km from the coast whereas the outer station was 112 km off shore. Lines were spaced 32 km apart and the grid was sampled from north to south on a continuous 24-hour basis. The position and depth of each station are given in Tables I and II respectively.

During the course of the investigation some interesting mesopelagic fish and juveniles of demersal and epipelagic species were captured in the plankton nets.

The net used on both surveys was a Bongo net 57 cm in diameter; paired nets of 0,94 mm mesh size were used on the first survey but on the second survey the left-side net had a mesh size of 0,94 mm and the right 0,50 mm. Oblique hauls were made at a speed of two knots from 50 m to the surface where the depth was sufficient, or from within a few metres of the bottom in shallow coastal waters (King and Robertson 1973). Survey number, cruise dates and station omissions are presented in Table III.

CATCH COMPOSITION

A total of approximately 1 300 fish were caught during the two surveys. Seven orders were represented, consisting of juveniles and adults of the families Clupeidae, Engraulidae, Gonostomatidae, Stomiatidae, Myctophidae, Scomberesocidae, Gadidae, Merlucciidae, Syngnathidae, Carangidae, Trichiuridae, Gobiidae, Blenniidae and Soleidae.

Fifty-three per cent of the total number of fish caught belonged to the species *Sufflogobius bibarbatus* (Percomorphi: Gobiidae), the order Percomorphi accounting for 61 per cent of the total

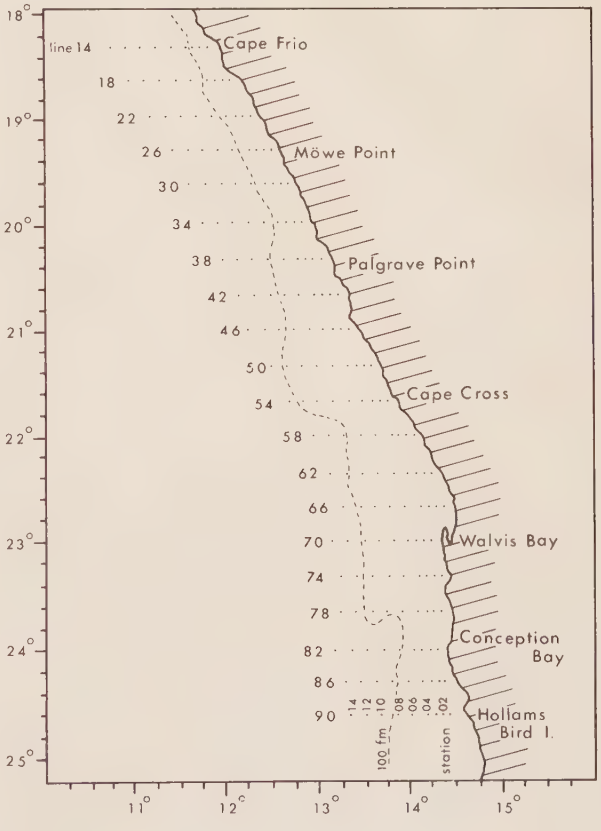

FIG. 1: LOCATION OF ROUTINE STATIONS OCCUPIED DURING THE SWAPELS CRUISES IN 1972/73 AND 1973/74

TABLE I: GEOGRAPHICAL POSITION OF EACH STATION

Line	Latitude	Station longitude								
		01	02	03	04	06	08	10	12	14
14	18°20′S	11°50′E	11°45′E	11°40′E	11°35′E	11°25′E	11°15′E	11°05′E	10°55′E	10°45′E
18	18°40′S	12°09′E	12°04′E	11°59′E	11°53′E	11°43′E	11°33′E	11°23′E	11°13′E	11°03′E
22	19°00′S	12°25′E	12°20′E	12°15′E	12°10′E	12°00′E	11°50′E	11°40′E	11°30′E	11°20′E
26	19°20′S	12°35′E	12°30′E	12°25′E	12°20′E	12°10′E	12°00′E	11°50′E	11°40′E	11°30′E
30	19°40′S	12°50′E	12°45′E	12°40′E	12°35′E	12°25′E	12°15′E	12°05′E	11°55′E	11°45′E
34	20°00′S	13°00′E	12°55′E	12°50′E	12°45′E	12°35′E	12°25′E	12°15′E	12°05′E	11°55′E
38	20°20′S	13°10′E	13°05′E	13°00′E	12°55′E	12°45′E	12°35′E	12°25′E	12°15′E	12°05′E
42	20°40′S	13°20′E	13°15′E	13°10′E	13°05′E	12°55′E	12°45′E	12°35′E	12°25′E	12°15′E
46	21°00′S	13°25′E	13°20′E	13°15′E	13°10′E	13°00′E	12°50′E	12°40′E	12°30′E	12°20′E
50	21°20′S	13°40′E	13°35′E	13°30′E	13°25′E	13°15′E	13°05′E	12°55′E	12°45′E	12°35′E
54	21°40′S	13°50′E	13°45′E	13°40′E	13°35′E	13°25′E	13°15′E	13°05′E	12°55′E	12°45′E
58	22°00′S	14°05′E	14°00′E	13°55′E	13°50′E	13°40′E	13°30′E	13°20′E	13°10′E	13°00′E
62	22°20′S	14°17′E	14°12′E	14°07′E	14°02′E	13°52′E	13°42′E	13°32′E	13°22′E	13°12′E
66	22°40′S	14°25′E	14°20′E	14°15′E	14°10′E	14°00′E	13°50′E	13°40′E	13°30′E	13°20′E
70	23°00′S	14°15′E	14°10′E	14°05′E	14°00′E	13°50′E	13°40′E	13°30′E	13°20′E	13°10′E
74	23°20′S	14°20′E	14°15′E	14°10′E	14°05′E	13°55′E	13°45′E	13°35′E	13°25′E	13°15′E
78	23°40′S	14°20′E	14°15′E	14°10′E	14°05′E	13°55′E	13°45′E	13°35′E	13°25′E	13°15′E
82	24°00′S	14°17′E	14°12′E	14°07′E	14°02′E	13°52′E	13°42′E	13°32′E	13°22′E	13°12′E
86	24°20′S	14°23′E	14°18′E	14°13′E	14°08′E	13°58′E	13°48′E	13°38′E	13°28′E	13°18′E
90	24°40′S	14°27′E	14°22′E	14°17′E	14°12′E	14°02′E	13°52′E	13°42′E	13°32′E	13°22′E

catch. Next in numerical abundance came the order Iniomi represented only by the family Myctophidae, with 27 per cent of the total. The greatest diversity was found in the family Myctophidae, represented by eleven species, three of which belonged to the genus *Diaphus*. The species *Lampanyctodes hectoris* constituted 60 per cent of all the myctophids collected and ranked second in overall species abundance (16 per cent of the total). Four species, namely *Notolychnus valdiviae* (Myctophidae), *Lampanyctus australis* (Myctophidae), *Diplophos taenia* (Gonostomatidae) and *Gaidropsarus capensis* (Gadidae) were each represented by a single specimen.

Sufflogobius bibarbatus (Gobiidae) was cap-

TABLE II: DEPTH (M) AT EACH STATION

Line	Station								
	01	02	03	04	06	08	10	12	14
14	34	104	140	200	570	1 400	2 000	2 500	3 000
18	36	40	92	134	212	240	460	960	1 370
22	45	90	102	120	210	270	294	330	660
26	42	72	104	126	180	260	310	340	510
30	45	84	102	116	144	226	306	360	435
34	40	80	105	120	150	220	272	334	410
38	46	92	114	120	140	260	290	306	424
42	40	85	108	122	152	270	310	322	490
46	32	80	110	118	170	300	362	430	600
50	21	75	93	106	130	164	310	358	530
54	33	64	90	106	128	150	240	300	355
58	26	44	72	93	115	140	175	220	310
62	22	43	66	85	110	125	146	210	236
66	26	50	78	94	120	129	134	218	282
70	62	102	114	126	140	148	208	345	325
74	42	80	112	125	154	162	176	268	270
78	34	76	110	140	172	190	226	260	330
82	64	102	128	154	232	258	275	290	470
86	28	80	108	128	154	284	324	334	668
90	38	58	70	98	148	155	320	420	655

TABLE III: SURVEY NUMBER, CRUISE DATES AND STATION OMISSIONS

Survey 1	Cruise	Omissions	Survey 2	Cruise	Omissions
1972: Aug. 22–31	1	Lines 14–34	1973: Aug. 14–19	1	Lines 14–34
Sep. 15–20	2	Lines 14–34	Sep. 9–15	2	Lines 14–18
Oct. 15–22	3	Stations 10,12,14 of Lines 30–50	Oct. 17–23	3	—
Nov. 11–19	4	—	Nov. 10–18	4	—
Dec. 5–14	5	—	Dec. 10–18	5	—
1973: Jan. 13–21	6	—	1974: Jan. 12–20	6	—
Feb. 14–24	7	—	Feb. 6–14	7	—
Mar. 11–19	8	—	Mar. 27–Apr. 4	8	—

tured at 50 stations, but species belonging to the family Myctophidae were collected at more stations (70) than any other family. *Lampanyctodes hectoris* was itself taken at 48 stations – more localities than any other myctophid.

The 71 juveniles of *Trachurus trachurus* taken at station 46-04 during November 1972 represented the largest number of individuals of a single species caught in a tow.

The distribution of some of the more significant species has been charted (Figs. 2 - 11).

ANNOTATED LIST OF SPECIES

A taxonomically arranged list of the fish species taken is given below. In the case of the more common species, the general distribution, length range, time of capture and temperature range are indicated. Records of the less common forms are listed under the species in the following abbreviated form: station of capture, survey and cruise number, number of specimens taken, standard length or length range of the specimen(s), time of day captured, sea surface temperature.

ISOSPONDYLI

Clupeidae

Sardinops ocellata Pappe

Juvenile pilchard were taken on only two occasions, approximately 25 km north-west of both Palgrave Point and Cape Cross (Fig. 2).

50-02, 1/4, (1), 62 mm, 03h48, 15,8°C
34-02, 2/5, (1), 56 mm, 01h30, 17,7°C

Engraulidae

Engraulis capensis Gilchrist

Anchovy juveniles were caught only twice –

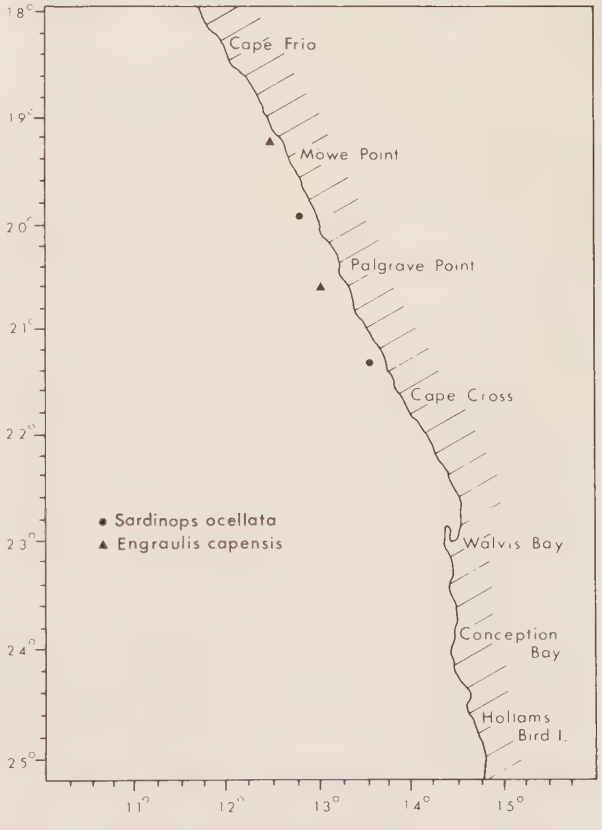

FIG. 2: LOCATION OF CAPTURE – *Sardinops ocellata* (CLUPEIDAE) AND *Engraulis capensis* (ENGRAULIDAE)

at approximately 25 km north-west of Möwe Point and 35 km south-west of Palgrave Point (Fig. 2).

26-02, 1/8, (6), 35-42 mm, 06h30, 16,1°C
42-04, 2/8, (4), 42-46 mm, 22h30, 18,1°C

Gonostomatidae

Maurolicus muelleri (Gmelin)

Juveniles of this species of lightfish were found 40 – 112 km off shore south of Walvis Bay (Fig. 3).

66-14, 1/4, (1), 33 mm, 17h08, 15,5°C
90-14, 1/4, (2), 19-28 mm, 05h50, 15,0°C
86-08, 1/7, (7), 22-35 mm, 20h18, 18,9°C
74-12, 1/8, (1), 27 mm, 21h50, 18,5°C
66-14, 2/5, (4), 23-26 mm, 23h56, 17,4°C

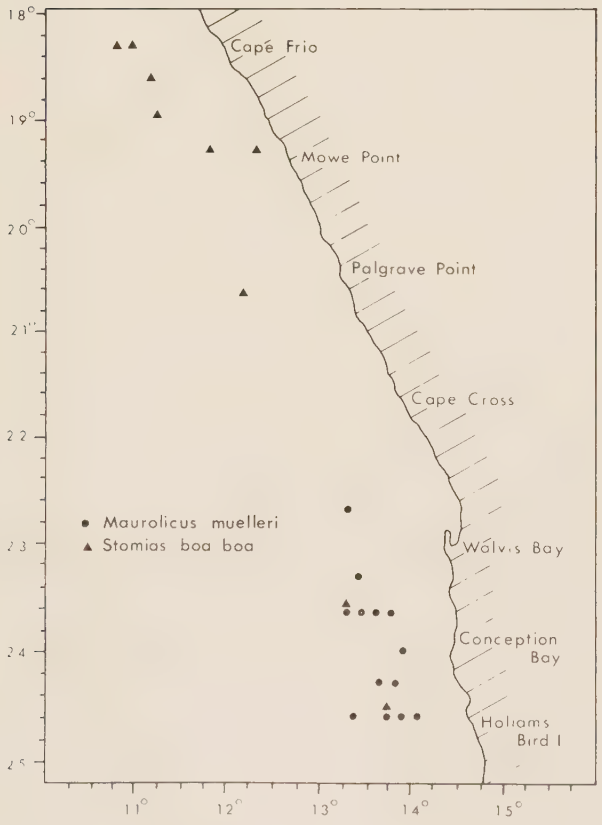

FIG. 3: LOCATION OF CAPTURE – *Maurolicus muelleri* (GONOSTOMATIDAE) AND *Stomias boa boa* (STOMIATIDAE)

82-06, 2/5, (1), 16 mm, 19h55, 15,0°C
86-08, 2/5, (2), 27 mm, 04h25, 14,0°C
86-10, 2/5, (2), 29-31 mm, 05h29, 14,5°C
78-08, 2/6, (1), 34 mm, 23h50, 17,6°C
78-10, 2/6, (4), 25-28 mm, 00h50, 18,2°C
78-12, 2/6, (2), 22-26 mm, 01h57, 18,6°C
78-14, 2/6, (2), 23 mm, 02h58, 18,6°C
90-08, 2/6, (15), 20-35 mm, 02h05, 17,1°C
90-10, 2/6, (1), 23 mm, 01h03, 17,5°C
90-06, 2/6, (5), 23-30 mm, 03h09, 17,0°C

Diplophos taenia Günther

A single juvenile was taken on one occasion approximately 85 km off shore in the northern part of the survey area.

22-10, 2/4, (1), 42 mm, 22h05, 18,5°C

Vinciguerria sp.

A single damaged specimen of this genus was captured at the outer station of the line on two occasions, but their state precluded identification to species.

42-14, 1/2, (1), 42 mm, 20h28, 14,8°C
14-14, 1/6, (1), 38 mm, 01h13, 18,6°C

Stomiatidae

Stomias boa boa (Risso)

Adults and juveniles of this predominantly deep-water species were caught mainly in the northern part of the research area (Fig. 3).

18-12, 1/3, (1), 112 mm, 05h40, 17,5°C
22-10, 1/4, (1), 42 mm, 04h30, 18,5°C
42-14, 1/5, (1), 89 mm, 21h30, 20,0°C
26-04, 1/7, (1), 113 mm, 08h20, 17,8°C
14-12, 1/8, (1), 33 mm, 03h25, 18,9°C
14-14, 1/8, (1), 66 mm, 04h26, 20,4°C
22-14, 2/3, (1), 92 mm, 20h01, 14,0°C
78-14, 2/6, (4), 105-130 mm, 02h58, 18,6°C
90-10, 2/6, (1), 58 mm, 01h03, 17,5°C

INIOMI

Myctophidae

Electrona paucirastra Bolin

Three juveniles of this species of lantern fish were captured on one occasion approximately 112 km west of Hollams Bird Island.

90-14, 1/4, (3), 31-42 mm, 02h10, 14,5°C

Hygophum macrochir (Günther)
Juveniles of this species were encountered only once, in the extreme north of the survey area.

14-12, 2/6, (3), 48-56 mm, 22h00, 21,3°C

Symbolophorus boops (Richardson)
Two species of *Symbolophorus, S. boops* and *S. veranyi* (Moreau), have been recorded from the South Atlantic. However, some confusion exists as to the validity of *S. veranyi* as a separate species (P. Hulley, S. Afr. Museum, personal communication). Differences in the pigmentation of the larvae of *Symbolophorus* collected during the surveys suggest two types, one associated with the Angola Current in the north and the other with the Benguela Current in the south. For the purposes of this report, however, all adults and juveniles caught are referred to as *S. boops*. *Symbolophorus* was widely distributed over the survey area and was the second myctophid in order of numerical abundance (Fig. 4).

66-14, 1/2, (1), 42 mm, 02h00, 14,5°C
82-04, 1/2, (2), 42-48 mm, 21h10, 14,8°C
18-14, 1/3, (1), 70 mm, 00h20, 17,8°C
26-06, 1/3, (3), 55-62 mm, 23h09, 15,9°C
22-08, 1/4, (2), 27-35 mm, 21h30, 18,0°C
30-12, 1/4, (2), 53-64 mm, 22h00, 18,2°C
82-12, 1/4, (1), 51 mm, 06h20, 15,9°C
82-10, 1/4, (1), 43 mm, 07h40, 15,8°C
90-12, 1/4, (1), 49 mm, 01h30, 15,7°C
22-08, 1/5, (1), 46 mm, 00h00, 21,0°C
30-10, 1/5, (1), 75 mm, 21h30, 20,4°C
34-14, 1/5, (1), 56 mm, 01h30, 20,2°C
42-10, 1/5, (1), 54 mm, 00h20, 20,1°C
42-14, 1/5, (1), 40 mm, 22h10, 19,8°C
50-14, 1/5, (1), 48 mm, 18h55, 18,6°C
14-14, 1/8, (1), 40 mm, 22h23, 20,9°C
14-12, 2/3, (2), 35-54 mm, 02h33, 16,0°C
26-10, 2/5, (1), 58 mm, 00h28, 19,2°C
34-08, 2/5, (1), 49 mm, 21h45, 18,7°C
34-12, 2/5, (1), 54 mm, 19h27, 19,3°C
22-12, 2/6, (5), 42-54 mm, 20h49, 19,4°C
46-10, 2/6, (1), 68 mm, 00h40, 20,0°C
58-14, 2/6, (1), 64 mm, 23h38, 18,8°C
78-14, 2/6, (1), 47 mm, 02h58, 18,6°C

Notolychus valdiviae (Brauer)
Juveniles were encountered twice in off-shore waters in the northern part of the research area.

22-14, 1/6, (1), 32 mm, 01h43, 18,3°C
14-12, 2/6, (2), 20-30 mm, 01h10, 20,4°C

Lampanyctus alatus (Goode and Bean)
Adults and juveniles were caught 80 - 112 km off shore in the north (Fig. 5).

14-14, 1/3, (1), 35 mm, 01h28, 17,5°C
14-12, 1/4, (4), 32-35 mm, 02h00, 17,4°C
14-08, 1/6, (1), 30 mm, 00h46, 18,0°C
50-14, 1/7, (1), 38 mm, 03h40, 20,7°C
34-14, 2/2, (1), 48 mm, 23h10, 15,5°C
50-14, 2/3, (1), 42 mm, 06h00, 15,5°C
14-08, 2/6, (2), 32-38 mm, 22h15, 18,1°C
18-14, 2/6, (1), 35 mm, 04h10, 18,0°C
26-14, 2/8, (1), 58 mm, 03h24, 20,6°C

Lampanyctus australis Täning
Only one juvenile specimen was taken 112 km west of Cape Frio (Fig. 5).

14-14, 1/3, (1), 24 mm, 04h20, 17,4°C

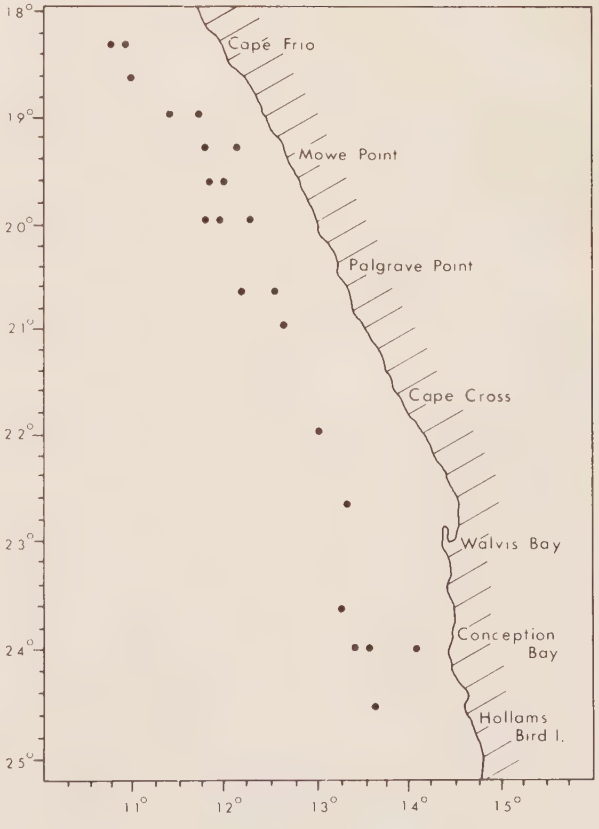

FIG. 4: LOCATION OF CAPTURE – *Symbolophorus boops* (MYCTOPHIDAE)

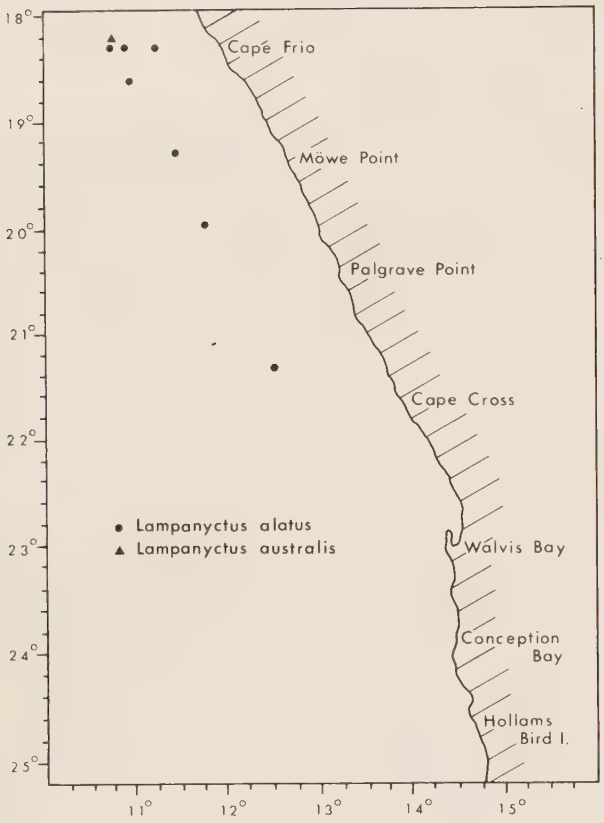

FIG. 5: LOCATION OF CAPTURE – *Lampanyctus alatus* AND *L. australis* (MYCTOPHIDAE)

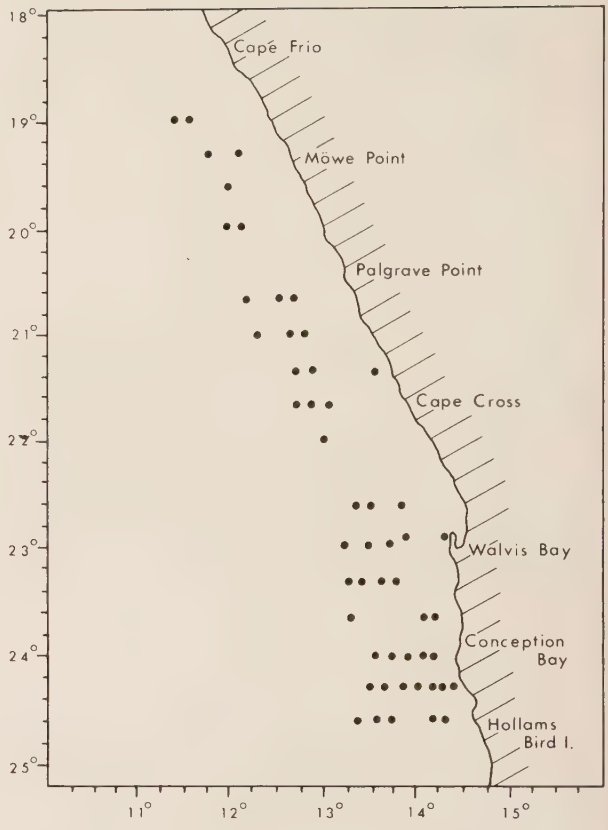

FIG. 6: LOCATION OF CAPTURE – *Lampanyctus hectoris* (MYCTOPHIDAE)

Lampanyctodes hectoris (Günther)

This species of lantern fish was the most commonly encountered myctophid and ranked second in overall species abundance. It was also the most common myctophid larva in the SWAPELS collections of ichthyoplankton (Ahlstrom *et al.* in press). Adult *L. hectoris* have been widely reported in the Cape from Lambert's Bay to Cape Agulhas and have been caught in commercial quantities in South Africa since 1969 (Centurier-Harris 1974).

A total of over 200 juveniles and adults ranging in size from 15 – 80 mm were caught. Although a few specimens were taken during every month, the species was most frequently encountered in August and September. The distribution extended from 19°00′S to 24°40′S but the majority were found 30 – 112 km off shore south of Walvis Bay (Fig. 6). Almost all the specimens were captured during the hours of darkness, with the greatest numbers taken immediately after dusk and between 01h00 and 03h00. *L. hectoris* occurred at temperatures of 12,0 – 17,5°C but were more numerous between 13,0°C and 14,0°C.

Diaphus cf. *theta* Eigenmann and Eigenmann

Juveniles were caught at the extreme off-shore station on three occasions.

14-14, 1/6, (1), 20 mm, 04h20, 20,8°C
42-14, 1/6, (1), 16 mm, 21h00, 19,2°C
18-14, 1/8, (2), 23-27 mm, 01h20, 20,0°C

Diaphus taaningi Norman

This species of lantern fish was caught regularly 60 – 112 km off shore between Cape Frio and Conception Bay and was the third most abundant myctophid in the collection (Fig. 7).

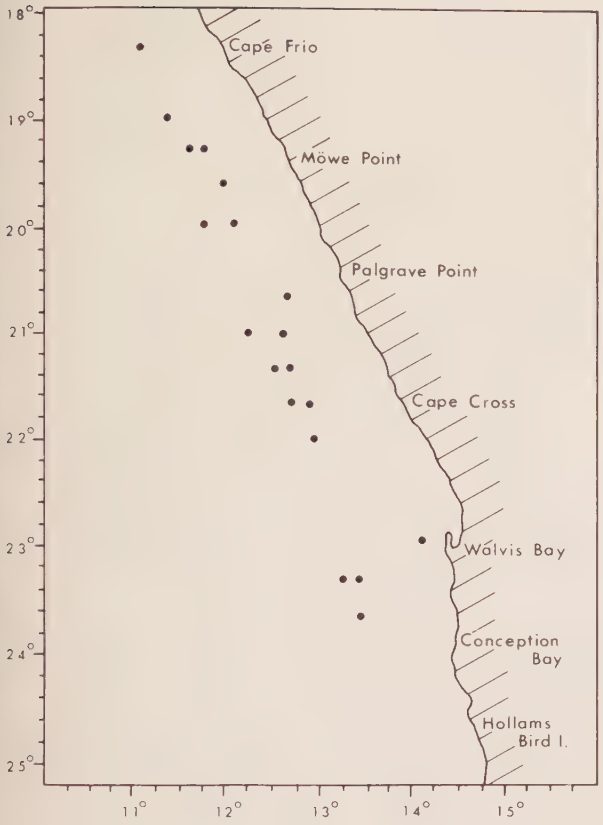

FIG. 7: LOCATION OF CAPTURE – *Diaphus taaningi* (MYCTOPHIDAE)

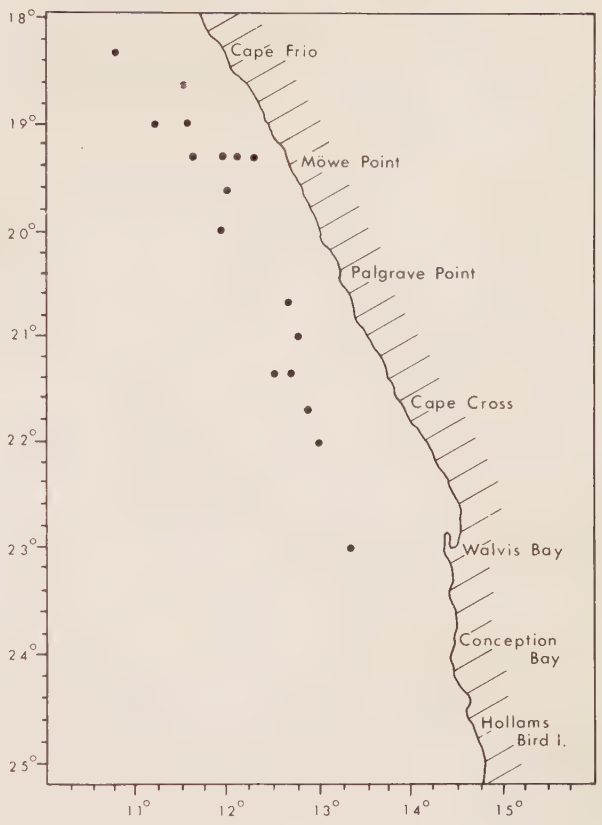

FIG. 8: LOCATION OF CAPTURE – *Diaphus dumerili* (MYCTOPHIDAE)

The specimens were mainly juveniles, ranged in size from 34 – 58 mm and were captured at night between 21h30 and 05h20. Most specimens were taken during the months of January, February and March when the water temperature lay within the range 18,5 – 20,7°C.

Diaphus dumerili(Bleeker)

This species was most frequently caught during February and March, 30 – 112 km off shore between Cape Frio and Walvis Bay (Fig. 8). The specimens were predominantly juveniles.

26-06, 1/3, (1), 32 mm, 03h55, 15,2°C
22-10, 1/4, (1), 43 mm, 23h13, 17,7°C
30-10, 1/4, (3), 22-43 mm, 21h05, 18,3°C
42-08, 1/4, (3), 18-32 mm, 23h30, 17,4°C
22-14, 1/6, (1), 19 mm, 04h20, 18,9°C
26-04, 1/7, (1), 21 mm, 08h48, 18,0°C
26-08, 1/7, (1), 35 mm, 06h25, 18,7°C
34-12, 1/7, (1), 42 mm, 00h15, 20,0°C
50-12, 1/7, (2), 37-42 mm, 03h40, 20,6°C
50-14, 1/7, (3), 25-46 mm, 02h35, 20,7°C
70-12, 1/7, (3), 32-54 mm, 00h30, 20,6°C
14-14, 1/8, (3), 16-18 mm, 22h23, 20,9°C
18-08, 1/8, (2), 29-35 mm, 05h03, 18,7°C
26-08, 1/8, (2), 52-59 mm, 02h16, 18,0°C
26-12, 1/8, (1), 18 mm, 23h52, 19,2°C
46-08, 1/8, (1), 42 mm, 02h30, 18,4°C
54-12, 1/8, (1), 51 mm, 00h45, 19,4°C
58-14, 1/8, (1), 67 mm, 23h40, 19,5°C

Myctophum sp.

Only eight specimens belonging to the genus *Myctophum* were caught during the two surveys, scattered widely over the grid.

74-12, 1/2, (1), 42 mm, 02h11, 14,0°C

86-14, 1/4, (1), 38 mm, 02h05, 16,0°C
14-08, 1/5, (1), 32 mm, 01h10, 18,6°C
14-14, 1/5, (2), 25-32 mm, 04h26, 20,4°C
18-14, 1/5, (1), 47 mm, 07h20, 19,0°C
46-14, 1/5, (2), 33 mm, 23h50, 20,9°C

SYNENTOGNATHI

Scomberesocidae

Scomberesox saurus (Walbaum)
Seven juvenile sauries were captured between 30 km and 70 km off shore between 19°S and 20°S (Fig. 9).

34-04, 1/8, (3), 42-45 mm, 00h20, 16,9°C
26-08, 2/2, (3) 43-44 mm, 06h00, 15,5°C
34-08, 2/2, (1), 62 mm, 02h48, 14,7°C

ANACANTHINI

Gadidae

Gaidropsarus capensis (Kaup)
One juvenile rockling was caught inshore in the south.

86-03, 1/3, (1), 25 mm, 13h50, 12,3°C

Merlucciidae

Merluccius capensis Castelnau
Juvenile hake were taken only during December, south of Walvis Bay (Fig. 9).

86-02, 1/5, (8), 25-32 mm, 00h10, 13,9°C
86-04, 1/5, (3), 28-30 mm, 05h10, 14,3°C
82-03, 2/5, (5), 28-35 mm, 20h50, 15,0°C
70-03, 2/5, (3), 27-28 mm, 10h28, 16,0°C
78-06, 2/5, (1), 23 mm, 08h18, 15,0°C
86-03, 2/5, (4), 28-32 mm, 01h40, 14,0°C

LOPHOBRANCHII

Syngnathidae

Syngnathus sp.
Three juvenile specimens of an unidentified species of pipefish were captured inshore between Möwe Point and Palgrave Point.

34-01, 1/5, (1),110 mm, 02h00, 16,5°C
38-01, 2/5, (1),123 mm, 04h20, 17,2°C

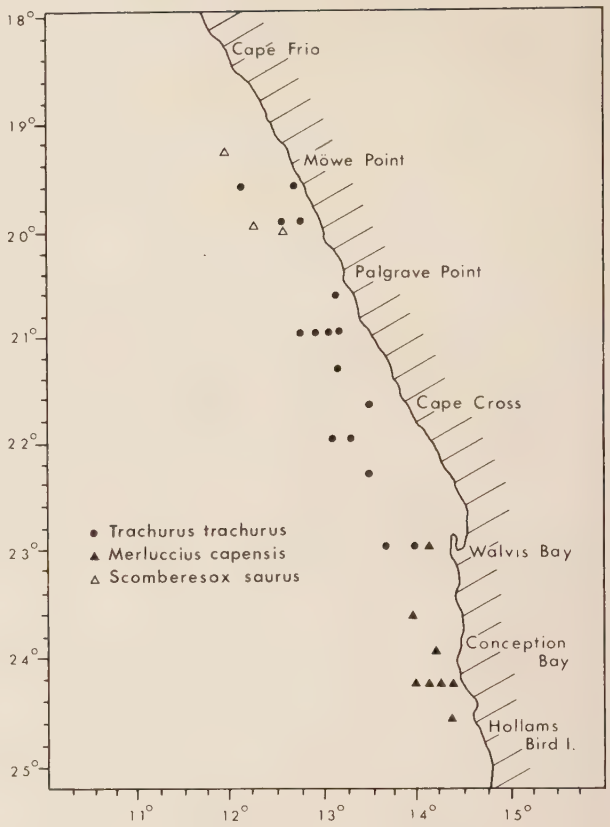

FIG. 9: LOCATION OF CAPTURE – *Trachurus trachurus* (CARANGIDAE), *Merluccius capensis* (MERLUCCIIDAE) AND *Scomberesox saurus* (SCOMBERESOCIDAE)

30-01, 2/7, (1), 100 mm, 01h20, 18,6°C

PERCOMORPHI

Carangidae

Trachurus trachurus Linnaeus
Juvenile maasbanker were caught on numerous occasions 8 – 80 km off shore between Möwe Point and Walvis Bay (Fig. 9). Greatest numbers were taken during November, February and March. Specimens ranged in length from 23 mm to 43 mm and were taken during day and night collections. However, most specimens were caught during daylight between 11h35 and 13h00. *T. trachurus* were found at temperatures ranging between 14,4°C and 20,0°C.

Trichiuridae

Lepidopus caudatus (Euphrasen)
Two juvenile frostfish were caught in the extreme north of the sampling area.

18-10, 2/7, (2), 22-25 mm, 23h35, 19,0°C

Gobiidae

Sufflogobius bibarbatus (Smith)
The bearded goby, *S. bibarbatus,* was previously only recorded from the southern coast of South Africa (Smith 1970). The species was first reported in South West African waters by Barber and Haedrich (1969), when they noted three juveniles off Hollams Bird Island. This record represents a 540-mile extension of the northerly limit of the species. Adults and juveniles were captured in large numbers during all months and ranged in length from 30 mm to 98 mm. The larvae of this species were also the most abundant in the ichthyoplankton collections during the two-year survey (O'Toole, unpublished data).

The northern limit of their distribution was at 19°20'S (Möwe Point) and specimens were found 8 – 85 km off shore (Fig. 10). The majority were, however, taken south of Walvis Bay between 8 km and 32 km off the coast. *S. bibarbatus* was found at temperatures ranging between 14,5°C and 17,5°C. The goby was taken mainly between 19h00 and 06h00, with peaks occurring at 19h00-21h00, 01h00-03h00 and 04h00-06h00.

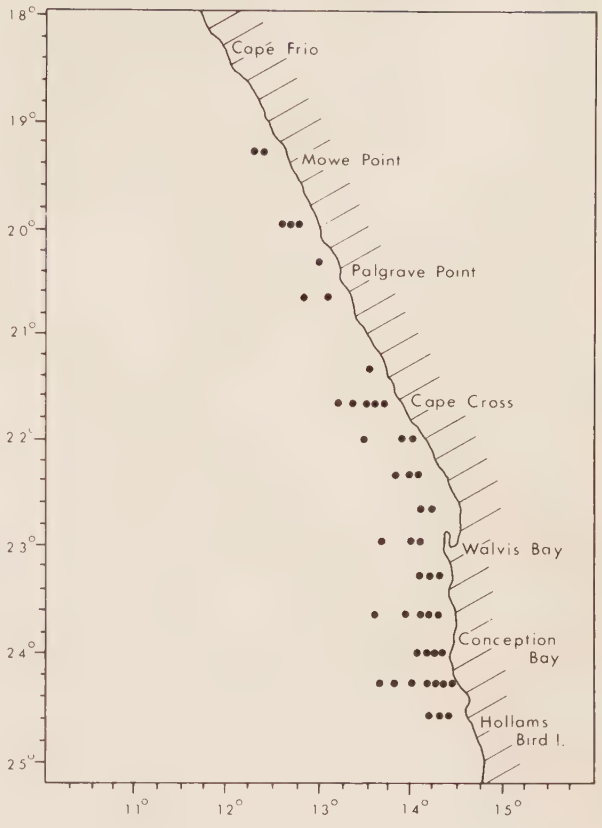

FIG. 10: LOCATION OF CAPTURE – *Sufflogobius bibarbatus* (GOBIIDAE)

Blenniidae

Chalaroderma capito (Cuvier)
This small specimen can only be tentatively identified at the present time (M. J. Penrith, State Museum Windhoek, personal communication). Larvae of this fish also were taken regularly.

18-12, 1/5, (1), 25 mm, 12h23, 21,5°C

HETEROSTOMATA

Soleidae

Austroglossus microlepis (Bleeker)
Four juveniles of the West Coast sole were captured in November and December, 8 - 40 km off shore in the Walvis Bay region (Fig. 11).

70-02, 1/4, (2), 25-26 mm, 04h05, 13,8°C
78-01, 1/5, (1), 28 mm, 06h45, 13,5°C
66-06, 2/5, (1), 24 mm, 04h20, 16,5°C

Dicologlossa cuneata (Moreau)
Juvenile Senegal sole were found only twice, inshore in the north (Fig. 11).

18-02, 1/6, (2), 26-27 mm, 15h00, 16,1°C
38-02, 1/6, (1), 31 mm, 12h15, 16,2°C

DISCUSSION

This report provides an indication of the presence and distribution of some fish species in the Benguela Current system between latitudes

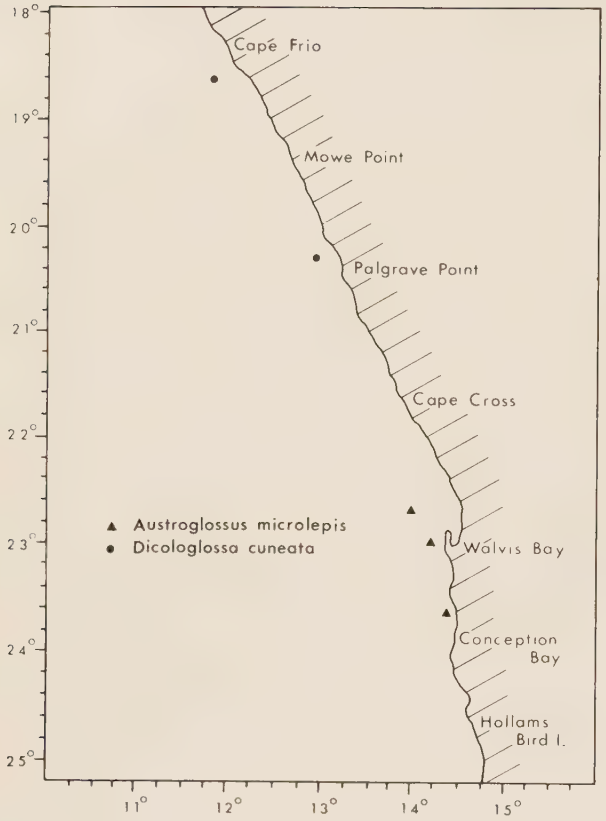

FIG. 11: LOCATION OF CAPTURE – *Austroglossus microlepis* AND *Dicologlossa cuneata* (SOLEIDAE)

18°20′S and 24°40′S. The bearded goby, *Sufflogobius bibarbatus*, has emerged as an important component of the neritic ecosystem, a fact which prior to these surveys had not been fully realized. Little is known about the biology or the behaviour of this species, although it has been shown to be a significant component of the scattering layer off South West Africa (Barber and Haedrich 1969; C. d'Arcangues, University of Paris, personal communication). Further study is needed on the biology of the species in order to establish its relationship with other species and with its immediate environment.

Net avoidance and diurnal migration appear to play an important role in determining the frequency of capture of some species. For example, juveniles of the pilchard and anchovy were rarely taken in the samples, probably owing to their ability to avoid slow-moving collecting gear. Those few that were captured were caught at night. On the other hand, juveniles of the maasbanker were taken frequently in the collections and did not exhibit any diurnal variation in catch-rate. This species would appear either to have a slow avoidance reaction or to be much more abundant than pilchard or anchovy in the upper 50 m layer during the day.

Adult gobies showed marked diurnal variation in catch frequency. Those examined in aquaria on board ship were observed to have feeble swimming ability. This fact, together with their apparent movement to the upper layers at night would explain their frequent appearance in the collections during the hours of darkness and their general absence from the upper 50 m layer during the day.

The lantern fish *Lampanyctodes hectoris* was captured at night and found to be the dominant myctophid in the survey region. Because of the existence of a new fishery for this species along the west coast of South Africa (Centurier-Harris 1974), a more detailed investigation could reveal its potential commercial significance off South West Africa.

Of the 25 species identified, 9 occurred only in the first survey, 3 only in the second survey and 13 were present during both surveys.

The geographic and seasonal patterns which emerged from these data will be examined more closely in a later report for their possible correlation with environmental and other biological parameters.

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A NOTE ON THE PRESENCE OF RIPE ANCHOVY OFF CAPE POINT

M. J. O'TOOLE

On 11 November 1975, large shoals of albacore (long-fin tuna) *Thunnus alalunga* were observed feeding at the surface between 24 km and 28 km south-west of Cape Point (Cape of Good Hope). Twelve specimens with a length (Lt) of 70–90 cm were caught by trolling from 09h00 to 10h30. The weights of the tuna varied from 12 kg to 21 kg and the surface temperature in the vicinity was 18°C.

Several freshly eaten anchovy *Engraulis capensis* were disgorged by some of the fish on landing and examination of one stomach revealed that the tuna had been feeding almost exclusively on this species. Five of the disgorged specimens were still in excellent condition and were examined for gonad activity. On slitting open the body cavity, the gonads of two (males) were in a white fluid condition and those of the other three (females) were both distended and fluid. All could be assigned to the ripe (stage 5) condition. The length (Lt) of the anchovies varied between 9 cm and 11 cm.

Spawning anchovy have never been recorded in commercial purse-seine catches in the Cape since 1963, the most advanced stage previously recorded being the active/ripe (stage 4) condition (Robinson 1966). The main spawning season of anchovy in Cape waters is during spring and summer. In recent years, most spawning has occurred east of Cape Point (Baird and Geldenhuys 1973).

Using data from surface tows only, Anders (1965) was able to determine the horizontal distribution and relative abundance of anchovy eggs off the Cape in the early years of commercial exploitation (1964/65). Ahlstrom (1959) noted that eggs and larvae of the northern anchovy *E. mordax* were to be found near the surface. Alverson (1961) stated that albacore occur mainly above the thermocline but his finding was modified by Kawai (1969) who stated that it is mainly the young specimens that are found in surface waters where the thermocline is shallow. Mr B. B. S. Tromp (Sea Fisheries Branch, personal communication) noted that the thermocline in the vicinity of these tuna shoals lay at 60 – 70 m when sampled routinely on October 27 and on November 13.

It appears probable, therefore, that the anchovies were not driven to the surface layers by the predatory tuna, but had, in fact, congregated, possibly for the purpose of spawning. The presence of both males and females in a ripe condition at the surface adds further weight to this hypothesis and it thus seems that both spawning and egg development take place close to the surface.

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